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TOWARD THE WORLD STATE*

By FREDERICK L. SCHUMAN

WOODROW WILSON PROFESSOR OF GOVERNMENT, WILLIAMS COLLEGE

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Three-quarters of a century later men have become fearfully aware of a wholly different type of impact of physics upon politics. They are everywhere perceiving, in a mingled mood of frustration and anxious urgency, that science has rendered obsolete many of the familiar habits which men have hitherto followed in the production and distribution of wealth and in the conduct of public affairs. The discovery is not new. William F. Ogburn long ago applied the apt term "cultural lag" to the reluctance of mankind to change social and political stereotypes at a tempo comparable to scientific and technological advance.

Fascism, from whose dominion of nihilism and homicidal mania the United Nations have freed themselves by the narrowest of margins and at a grievous cost, is itself a product of this schism. The new Caesarism flows from man's incapacity to change his institutions in such wise as to use his enormously increased productive resources for wealth and welfare. The idleness of men and machines amid potential plenty breeds

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bitterness and hatred, driving its victims finally into insane cults of fear and rage and into programs for keeping all machines and men busy preparing destruction and death. It could happen here or in any community where men as producers, consumers, and citizens suffer self-defeat through their own timid conservatism and nostalgia under the pressure of the forces released and the problems posed by the daring radicalism and inventiveness of men as scientists and engineers.

What is new is the realization that the latest triumphs of physics spell either the advent of a Golden Age in which mankind will make all the earth a garden and reach out among the stars —or the immolation of modern civilization in a vast holocaust. The former result requires a revolutionary transformation of almost all the social devices of old, particularly those for ordering (or disordering) the relations among the nation-states. The latter result will eventuate with almost mathematical certainty from efforts to cling to dogmas and practices which are now as irrelevant as the folkways of those who lived in Ninevah and in Ur of the Chaldees.

Awareness of the alternatives breeds not hope but panic, slowly spreading in a tide of fear over the globe. For it is already plain that the minds of men, and especially of politicians, diplomats, and strategists who have vested interests in the *status quo,* stubbornly resist all appeals to revolutionize the world community, even though conservatism now spells the end of all that men hope to conserve. As in all times of troubles, fear moves the majority of the frightened to cling frantically to the fancied safety of the past rather than embark upon the unknown seas of the future. The inescapable fact remains that men have found means of verifying Einstein's hypothesis of 1905: $E = mc^2$—that is, energy, when converted from matter, equals mass multiplied by the square of the speed of light. Four pounds of U–235 or plutonium can heat and light a city by methods which will be perfected within a decade. The same four pounds, by methods already perfected, can destroy a city and convert most of its buildings and citizens into radioactive fumes and ash.

Mars and Pluto. That an atomic war means the end of civilization has already become a truism. "An armament race in atomic weapons, which now seems indicated," writes Chancellor Robert M. Hutchins, of the University of Chicago, in his annual report for 1945, "can lead only to the extermination of mankind; for no one can seriously suppose that the horror of war can prevent war." Some remnants of mankind, to be sure, would survive in areas still habitable and remote from the rubble-strewn wastes of the great metropolitan centers. But "civilization," which is literally the product of city-dwellers and not of countrymen or troglodytes, would scarcely survive the debacle. The mode of life of those still alive may well recall the words of Oswald Spengler:

> Man becomes a plant again, adhering to the soil, dumb and enduring. The timeless village and the "eternal" peasant reappear, begetting children and burying seeds in Mother Earth. . . . In the midst of the land lie the old world-cities, empty receptacles of an extinguished soul, in which a historyless mankind slowly nests itself. Men live from hand to mouth, with petty thrifts and petty fortunes, and endure. Masses are trampled on in the conflicts of the conquerors who contend for the power and the spoil of this world . . . while those in the depths pray, pray with that mighty piety of the Second Religiousness that has overcome all doubts forever. . . . It is a drama noble in its aimlessness, noble and aimless as the course of the stars, the rotation of the earth, and alternance of land and sea, of ice and virgin forest upon its face. We may marvel at it, or we may lament it—but it is there.

It may be taken as a certainty that such a condition of human affairs will

come to prevail in most of the lands of the Northern Hemisphere in the event of an armed conflict of any duration among Great Powers possessing atomic bombs. The war god now wields a weapon containing the flaming fury of the sun and the cosmic power of creation and doom that burns in the farthest stars. By its use, he can swiftly deliver most of the centers of civilization into the hands of the god of death, who is likewise the god of wealth and the deity whose name has been given to the remotest planet and to the new element whereby man may destroy himself.

Only those given to a naive and tragic optimism will suppose that the danger can be averted through treaties among sovereign states outlawing particular weapons or "outlawing war." The former procedure is feckless in the age of total war. The latter is fruitless in any age in any state system composed of separate sovereignties acknowledging no higher power. It was attempted in 1933 by many states in the "Argentine Anti-War Pact." It was attempted in 1928 by all states in the Pact of Paris and in 1919 by most states in the Covenant. It was attempted in 1280 B.C. by Egypt and the Kingdom of the Hittites in the first treaty of which the text remains. The result in every case was the same.

Anarchy and Order. "We are aware," declared President Truman and Prime Ministers Attlee and King in their statement of November 16, "that the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war." The problem of preventing war is not a logical, but purely a psychological, problem. In logic and in all past experience, the problem has invariably and unmistakably pointed toward its own solution. War—i.e., the use of armed violence by organized groups against other groups—is possible only in a community suffering from anarchy. Anarchy is the absence of government. Under anarchy, in Thomas Hobbes' memorable phrase, human life is "solitary, poor, nasty, brutish and short." This is so because all politics under anarchy is "power politics"—i.e., a struggle for control of the means of armed coercion, since all know that violence will be ultimately decisive in determining the distribution of indulgences and deprivations. In a community lacking government the assumption of violence permeates every motive and act of those who are obliged to play politics. And in such a community men bargain over, and fight for, anything which they believe will add to their own fighting capacity and diminish that of rivals and enemies.

The Western State System is obviously such a community. It has always been such a community since the disintegration of the Roman World State and the fading of the medieval ideal of a universal church and a universal empire. To call attention to the obvious would be unnecessary were it not for the prodigious capacity of men to ignore it. International anarchy is not banished by making treaties nor by setting up alliances or leagues resting on the premise of national sovereignty. No community can have government when its separate parts each claim prerogatives admitting of restrictions only on the basis of "international law"—i.e., customs and contracts acceptable to sovereigns and observed only insofar as habit, expediency, good faith, or force may dictate obedience. In extremities all such restraints yield to the imperatives of survival in a brute struggle of each against all.

This fact has long been appreciated by almost all who have given serious thought to the cause and cure of war. The unwillingness of most of modern mankind, even in the atomic age, to acknowledge the fact does not abolish it

nor change the terms of the problem. Unlimited national sovereignty inevitably means international anarchy which inevitably breeds power politics and war. War can be prevented only by abolishing power politics—a consummation wholly beyond realization through moral exhortation or national professions of righteousness. Power politics can be abolished only by replacing anarchy by government in the world community.

The essential attributes of effective government are equally plain and beyond debate. Government has never been achieved, and can never be achieved, through contractual obligation among collective entities, all envisaged as equals and each possessed of paramount power within its frontiers. Neither is government produced by agreements among sovereignties to keep the peace through the collective coercion of peace-breaking sovereignties at the hands of peace-loving sovereignties. This formula of "collective security" was rightly dismissed by Alexander Hamilton as "one of the maddest projects ever devised." Government presupposes an organized authority which is superior, within its defined area of action, to any other authority in the community. It further presupposes that the superior authority will enjoy a decisive preponderance (and, indeed, usually a monopoly) of armed power, and that it will be able to lay down rules of law addressed to, and enforceable upon, individuals rather than upon nations or states. Legislation, administration, and adjudication are prerequisites of all government capable of governing. To talk of government in terms of arrangements falling short of these essentials is to indulge not in an adventure in creative statesmanship but merely in an exercise in humor, hypocrisy, or cynicism.

That global government and unrestrained national sovereignty are mutually exclusive is too obvious to require further proof. Yet demands for the "abolition of sovereignty" are vain since men's minds and hearts are still firmly fixed upon this sacred symbol. What is needed is patient demonstration that in the atomic age all the blessings of sovereignty are mortgaged to the worms through continued anarchy and can only be saved by delegating a limited portion of sovereignty to a supranational authority. In the words of Anthony Eden to Commons (November 22, 1945): "For the life of me I am unable to see any final solution that will make the world safe from atomic power other than that we will abate our present ideas of sovereignty."

Peace By Conquest. One method of abolishing international anarchy is for one sovereignty to subjugate all others. Such was the achievement of ancient Rome in the Mediterranean State System and of the Khans of Tartary throughout most of Eurasia fourteen centuries later. Such, *seriatim,* were the frustrated aspirations of the House of Hapsburg, the France of Bourbons and Bonapartes, the Germany of the Hohenzollerns and Hitler, and the Japan of Hirohito. Thus far, in the Western State System, each aspirant to universal hegemony has ultimately been beaten down by a coalition of all other Powers against it. If past experience is any guide to the future, it can be taken for granted that no single Power will ever be able to establish world government by the sword.

But here, too, the atomic bomb invalidates many past calculations of probability. Had Nazi or Nipponese scientists first perfected the new weapon, it is all but certain that the Fascist coalition would have inflicted a crushing defeat on the United Nations and would have undertaken the establishment of some semblance of global government, based

on slavery and genocide. Speculations as to whether, or how long, such an order might have endured would be futile. The invention of the bomb in America means that the United States has acquired—for a limited period of years, until other Powers begin production—the hypothetical possibility of unifying the world by violence.

The mere mention of the prospect evokes panic among non-Americans and indignation among Americans. Nothing is clearer (to Americans) than the impossibility of the United States attempting to build a *Pax Americana* or an "American Century" by utilizing the bomb to extinguish other sovereignties. Yet other peoples know that democracy is no guarantee against aggression and that in the past the United States has in fact waged campaigns of aggrandizement, behind appropriate façades of morality and self-denial, in Mexico, Cuba, the Philippines, Nicaragua, Panama, and elsewhere, as has Britain in virtually every region of Africa, Asia, and Oceania. With an irresistible weapon temporarily at their sole disposal, Americans might be expected by many abroad to give serious consideration to a program of abolishing all other sovereignties.

That this eventuality is not thus far on the horizon is doubtless due to a combination of rectitude, realism, ineptitude, and indifference. The citizenry of the Republic has displayed commendable capacity to resist temptation. Reflective strategists know that America will be weakened, not strengthened, when atomic weapons are available to other Powers, for America's geographical security against foreign attack will be at end, while America's concentration of industry and population along a narrow corridor between Boston and St. Louis will render it peculiarly vulnerable, albeit less so than Britain. Should a bid for world-wide hegemony fail, its aftermath would be catastrophic. The Government of the United States, furthermore, has no affirmative program in foreign policy which could be implemented by atomic diplomacy and strategy. Its spokesmen have preferred during the months following World War II, as during the years preceding it, to take refuge from the need of having a policy in frequent reiterations of pious platitudes and noble negatives. The legendary "average citizen," moreover, would appear to be too preoccupied with sports, sex, and the quest for private security or riches to have any interest in imposing the American way of life on the rest of the planet through the medium of nuclear fission.

Yet an America reduced to desperation by a new business debacle, followed by prolonged economic stagnation, could conceivably be educated to the advantages of global conquest. But such a disaster, should it occur, might take place at a time when the Soviet Union and other states were already producing atomic bombs in sufficient quantity to retaliate. And a Fascist America, even if "victorious" amid a blasted world, would be as deficient in those qualities of vision, imagination, and moral purpose essential to unify the world by force as were the late Triplice Powers. The effort, even if successful, would engender fierce resentments among millions of its victims. A few score of the vengeful, carrying atomic infernal machines in suitcases, would be able with ease to demolish the major cities of the Republic, assuming that the great metropolises had escaped annihilation in the course of hostilities by virtue of America's temporary monopoly of the bomb. All things considered, the building of a World State by force is no more possible in the atomic age than in the preatomic age. What was once done by the Roman legions and by the invincible cavalry of the Mongols cannot be re-

peated in our time either by the United States or by Britain or by the USSR. This road to world peace through world government is blocked.

Peace By Federalism. The only other available means of achieving a goal which now deserves to be regarded as the *sine qua non* of survival is the application to the world community of those unique principles of governance formulated most impressively by the Founding Fathers of the United States and long since applied in many areas of the British Commonwealth and throughout the USSR. In each case the problem was the same as the world problem of today: how to achieve effective central authority in a society of separate sovereignties without risking the enslavement of the parts by the whole or the enfeeblement of the whole by the parts. The answer is federation.

This prescription for the cure of anarchy is by no means novel, even if its urgency has only now become desperate. Without recalling numerous earlier proposals, it is noteworthy that Theodore Roosevelt urged the need of an "International Police Power" in 1910 and that Hamilton Holt, about the same time, asserted that "the United States must become the model of the United Nations of the World." In 1919 Frederick Jackson Turner warned Woodrow Wilson that any effective international organization must restrict national sovereignty and possess legislative authority. With this proposition the President doubtless agreed in principle, though he saw no way then of obtaining American approval for anything beyond a League—and even in this his optimism proved excessive. More recent pleas for federalism by Clarence K. Streit, Robert Lee Humber, Ely Culbertson, Mortimer Adler, and many others have been followed, since the horror of Hiroshima and Nagasaki, by widespread appeals from physicists, publicists, political scientists, and even a few rare politicians for steps to establish a world federal government as the only visible alternative to mass suicide.

Confusion and befuddlement, both in semantics and in politics, can be minimized by keeping before public attention the precise nature and meaning of federation. Since all Americans, many British subjects, and all Soviet citizens live under federal governments on a national level, it might be supposed that all would possess at least a working familiarity with federal principles. Even casual inquiry, however, reveals that this is far from being the case.

Suffice it to say for present purposes that a federal government is one in which powers of legislation, plus appropriate executive and judicial functions, are divided between central agencies and local units by means of a written constitution which cannot be changed either by the local units or the central organs alone, but only by a process of joint action on the part of both. The central, or "federal," agencies are typically entrusted with limited, specified, or delegated grants of authority, circumscribed by more or less elaborate safeguards against extension or abuse, with all residual powers left to the governments of the local areas or to the people of the union. True federalism likewise involves duel citizenship, since every individual within the jurisdiction and in full possession of civic rights acquires privileges and duties both as a citizen of his local area and of the union as a whole. Federalism also presupposes two realms of law (e.g., State and Federal in the United States, Republican and Union in the USSR), with both bodies of law enforceable on individuals in courts, with all local officials answerable for the observance of federal as well as local law, and with federal treaties, the Union Constitution, and all federal stat-

utes enacted in pursuance thereof given the status of a "supreme law of the land," which all courts are bound to enforce against any conflicting local legislation.

Such arrangements are the antithesis of the traditional concept of "collective security"—i.e., the coercion of sovereign states by other sovereign states or by central agencies set up by them. The judicial application of law to individuals has almost nothing in common with the collective enforcement of treaties on sovereignties, as the framers of the American Constitution clearly recognized. The former process exhibits innumerable instances of its successful use as a means of promoting the rule of law and maintaining order and peace. The latter process, whenever resorted to among "Great Powers," has always led to failure, either through war or through general acquiescence in the violation of obligations. The abandonment of the forcible coercion of states, and the adoption in its place of the restraint of individuals through action by law-enforcement authorities on all levels of government, is the essence of all genuine federalism.

The Art of the Possible. Nothing is simpler for those disposed to accept the argument thus far than to demand a World Federal Government at once, or at least a global Federal Union of Democracies. Such was the procedure of the distinguished participants in the conference at Dublin, N. H., on October 16, 1945. The majority resolved that the UNO should be replaced, either through drastic amendments to the Charter or through a new World Constitutional Convention, by a World Federal Government with a Legislative Assembly, and Executive and a Judiciary. A minority, including Owen J. Roberts and Clarence K. Streit, urged that "simultaneously with efforts to attain a world federal government, the United States should explore the possibilities of forming a nuclear union with nations where individual liberty exists, as a step toward the projected world government."

The proposal of a federation of democracies, while relevant to the exigencies of 1939–40, is not only irrelevant in 1945–46 but deserves to be regarded (were there any possibility of favorable action upon it) as fatal to the larger project. In a world in which the United States and the Soviet Union are the two greatest Powers, and in which any progress toward peace and order requires harmony and unity between them, any project of an Anglo-American Union would be envisaged by all Russians and by many people elsewhere as a maneuver against the USSR. Regardless of the intent of its architects, this would inescapably be its actual role in power politics. This game of the anarchists can obviously not be ended by any federation excluding any of the major Powers. "Union Now With Britain" would thus foster in its most dangerous form a global rivalry which would almost certainly preclude any advance toward a World Union.

Soviet acceptance of Western definitions of liberty, moreover, is not at all a prerequisite of a federation embracing Washington, London, and Moscow. The need of the hour is not a world bill of rights guaranteeing civil liberties, desirable as such an ultimate goal may be, but the delegation of legislative power over atomic energy to a world agency. Ideological and institutional differences are no obstacles to the enterprise if the governments and peoples of all the Super-Powers can be brought to see the shape of the most probable alternative. There can be no future for liberty anywhere if an atomic war comes to pass. Its prevention requires the prevention of war. This task requires redefinitions of liberty everywhere and a world fed-

eration, initially limited in its grant of power to the specific function of making atomic energy the servant and not the destroyer of the race.

On the broader issue, considerations of political psychology and strategy suggest the unwisdom of demands for "scrapping" the UNO, despite its obvious inadequacies. The Philadelphia Convention of 1787, to be sure, displayed sound judgment in abandoning the Articles of Confederation and embarking upon a wholly new departure In such matters it is often true, as Lloyd George once observed, that "nothing is more dangerous than to try to leap a chasm in two jumps." On the other hand, no world constitutional convention is politically conceivable until after the UNO has been established and subjected to several years of trial. The amending process in the Charter (cf. Art. 109) offers the possibility of early action. Prevailing attitudes render the implementation and progressive reform of the UNO in the direction of federalism a far more feasible undertaking than the abrupt repudiation of what has already been done and the creation *de novo* of an alternative scheme.

In neither course can there be full assurance of safety nor even of progress toward the goal. Men are easily victimized by blind fears and fatuous hopes amid the atomic world revolution of our time. But the very magnitude of their anxiety and the diversity of their confused quests for salvation would seem to dictate a pattern of action which will minimize the alarms bred by proposals for revolutionary change and maximize the reassurances which go with stability, continuity, and orderly reform.

How to Begin. In all human journeys, as Alice was once sagely informed by the Cheshire Cat, the wayfarers are likely to approach their destination only when they know where they wish to get to, where they are, and where they have come from. Progress in the present enterprise will be proportionate to the knowledge of the travelers not only of the principles of federalism but of the nature and purport of the UNO.

The new organization is clearly not a government but a league of sovereignties. It differs from the Geneva League, however, in one vital respect. The framers of the Charter abandoned the unworkable device of keeping the peace through the assumption of duties by all sovereigns to apply collective coercion against any sovereign that might break the peace. In its place was put the principle of the unity of the Great Powers America, Britain, and Russia (the Super-Powers), along with France and China (the pseudo-Powers), are pledged not to attempt coercion of one another and to apply collective coercion against others only when they are of one mind among themselves and also have the approval of two of the six nonpermanent members of the Security Council.

The meaning of the "veto" in the Yalta formula and in Article 27 of the Charter is that collective measures of enforcement for keeping the peace shall be applied only on the basis of unanimity among those sovereignties which alone are possessed of decisive power. None of these can be coerced by any or all of the others without a major war. None of these can coerce outside sovereignties against the will of any or all the others without promoting the rivalries among the powerful which lead to war. The objective is peace. Hence the wisdom of necessity of unanimity among the permanent members of the Security Council, which can be effective only insofar as it functions as an executive committee of united Great Powers.

If these considerations, already signed and sealed in the Charter, are taken as a point of departure for next steps, then it is evident that what is needed

and what is possible for the transitional period immediately ahead is a redefinition of the authority of the Security Council, without (at this stage) any change in its composition or voting procedure. The Council is charged by Article 24 with "primary responsibility for the maintenance of international peace and security." This responsibility plainly cannot be discharged without authority over the use of atomic energy on a world scale. To transfer such authority elsewhere would reduce the Council to a shadow. To envisage such authority in terms of advice to governments to conclude treaties "outlawing" war or prohibiting atomic bombs would be to misconstrue entirely the nature of the problem and the experience of the past. What is called for—if the current issue is to be met adequately and if the ultimate goal is to be served effectively—is the grant to the Security Council of legislative power in the field of atomic energy.

Such a departure from precedent presupposes an initial agreement among the Super-Powers, followed by a global accord acceptable to France, China, and the other United Nations. Specific, limited but adequate power to enact statutes regarding atomic energy can readily be conferred upon the Security Council through the device of a general treaty. Such statutes must become part of the supreme law of the land in all member states, enforceable on individuals through national and local courts, with the International Court of Justice having ultimate appellate jurisdiction. Global atomic legislation cannot as yet be enacted by majority vote. The Council as constituted under the Charter could best enact its statutes by the procedure already provided in Article 27—i.e., unanimity among the permanent members, plus assent by any two of the other six.

Nothing more than this is needed to begin the building of a federated world. Nothing less than this will suffice to cope with the problem of the atomic bomb. However inadequate such a procedure may appear to those concerned with democratic values and majority rule, it would seem to represent the only acceptable procedure for the immediate future. Given this, reforms and advances will enter into the realm of the politically possible. Without this, all the days ahead may be wasted in wrangling and vain illusions while an atomic arms race gains headway and drives the nations along the road to death.

How Not to Begin. The decisions and indecisions in high places during the half-year following the vaporization of Hiroshima and Nagasaki present the general appearance of a perfect formula for frustration and ultimate tragedy. The physicists, to be sure, have displayed a large measure of vision, maturity, and responsible statesmanship. Almost with one voice they have insisted that there is no "secret," that no defense against the bomb is possible, and that no control can be effective save through a world authority. In a statement of November 16, the Federation of Atomic Scientists realistically urged an Anglo-American-Soviet conference to propose measures of international control for submission to the other United Nations. The majority of politicians, on the other hand, have displayed a consistent preference for daydreams, nightmares, and nonsense.

Aside from various fatuous proposals already noted, all schemes to vest control of atomic energy in the General Assembly of the UNO fall into this category. The contention that such a procedure would be "democratic" is wholly without merit. Democracy assumes the equality of people. The rule of the equality of sovereign states is the negation of democracy by any definition. An Assembly of

sovereign equals would be one in which Albania, Yemen, Luxembourg, and Guatemala had the same voice and vote as China, Russia, America, and Britain. Such a body, moreover, can never be anything more than an irresponsible congeries of the impotent, certain to reenact the evasions and failures of Geneva. To divorce responsibility from power is to insure disaster.

The Truman-King-Attlee declaration of November 16, 1945, is scarcely more encouraging. Its framers rightly concede in their preamble that "no adequate military defense" against the bomb is possible; that "no single nation can in fact have a monopoly" of its use; and that "no system of safeguards that can be devised will of itself provide an effective guarantee against production of atomic weapons by a nation bent on aggression." But the leaders of Atlantica then seek to distinguish between the use of atomic energy for military purposes and its use for peaceful, industrial purposes. The distinction has no present or immediately prospective reality since the only practicable use of atomic power thus far is for war. Sovereign states, moreover, are inexorably driven to use all resources and techniques for military purposes when confronted by total war. Despite their recognition that "the military exploitation of atomic energy depends, in large part, upon the same methods and processes as would be required for industrial uses," the framers of the declaration base the balance of their statement upon a fictitious dichotomy, offering to exchange scientific information "for peaceful ends with any nation that will fully reciprocate"; declaring (inconsistently) that "scientific information essential to the development of atomic energy for peaceful purposes has already been made available to the world"; and finally proposing (with even greater inconsistency) to "share, on a reciprocal basis with others of the United Nations, detailed information concerning the practical industrial application of atomic energy just as soon as effective and enforceable safeguards against its use for destructive purposes can be devised."

In this jumble of false premises and contradictions, nothing is clear save the decision of the authors to share something which is nonexistent in return for something they acknowledge to be unattainable. The *quid* is information on the "peaceful" or "industrial" use of atomic power which, as of 1945–46, is many years off. The *quo* is a system of "effective, reciprocal, and enforceable safeguards acceptable to all nations" and already conceded in the statement itself to be beyond achievement.

The cream of the jest is to be found in the tasks assigned, *seriatim*, to the proposed UNO commission—i.e., to make recommendations and proposals:

(*a*) For extending between all nations the exchange of basic scientific information for peaceful ends.

(*b*) For control of atomic energy to the extent necessary to ensure its use only for peaceful purposes.

(*c*) For the elimination from national armaments of atomic weapons and all other major weapons adaptable to mass destruction.

(*d*) For effective safeguards by way of inspection and other means to protect complying States against the hazards of violations and evasions.

The first assignment is pointless, since there is as yet no "basic scientific information" relative to atomic energy "for peaceful purposes," and if there were the only obstacle to its world-wide dissemination would lie in the present policies of the American, Canadian, and British Governments. The remaining charges to the Commission can only be regarded as ludicrous or meretricious. There is no way in a world of fully sovereign states of insuring the use of atomic power "only for peaceful purposes," nor of eliminating weapons of mass destruction from national arma-

ments, nor of establishing effective safeguards against the use of such weapons. If the members of the Commission are alert and honest, they will report that the duties assigned them are impossible within the frames of reference of existing scientific knowledge and the reign of unrestricted sovereignty among the nations. If they are dishonest or naive, they will indulge in further circumlocutions. The task of mastering the bomb cannot be begun until those in high places abandon old stereotypes and new fantasies and face stubborn facts.

The Dawn of a Hope. The Moscow Conference of December 16–26, 1945, opens new prospects for progress. The false choice of "keeping the secret" or "giving the bomb to Russia" was ignored by Byrnes and Bevin, who sagely devoted their efforts to restoring the crumbling foundations of Anglo-American-Soviet collaboration. Upon this base must rest all hope for the UNO today and for world government tomorrow. The new compromises dispose, at least partially and temporarily, of the twin bogies of Soviet "isolationism" and of Anglo-American "atomic diplomacy" against the USSR. The Moscow formula on atomic energy saves all faces and removes many obstacles in the way of further advance. The Kremlin associates itself with the proposals already made by Washington, Ottawa, and London. The UNO Commission will be sponsored by the Big Three, plus France, China, and Canada. It will be established by the General Assembly but will consist of states represented on the Security Council (plus Canada) and will act under the direction of, and report to, the Security Council.

The Commission, to be sure, is charged anew, by the resolution voted by the Assembly in January, with the same four tasks which remain, as before, impossible of accomplishment in an ungoverned and ungovernable world of sovereign equals. But it is further asked to "inquire into all phases of the problem and make such recommendations from time to time with respect to them as it finds possible." The immediate future depends upon the disposition of the Commission to avail itself of its opportunities under this enlarged grant of advisory authority. If it limits itself to conventional platitudes and traditional devices, thousands will cheer—but millions will suffer eventual disenchantment and all-but-certain tragedy. If it boldly proposes the provisional vesting of legislative power over atomic energy in the Security Council, many will denounce its suggestions in 1946, but all will bless its work in the years and decades which lie ahead—assuming that the UNO makes such proposals the guideposts of the new age.

Upon the willingness of the world community to take this decisive step depend man's hope and man's fate. The primary obligation is more than ever that of the United States. America's duty is likely to be creatively fulfilled only if Americans perceive and insist upon the need for global legislation, and only if they abandon their fictitious monopoly of "secrets" and their actual monopoly of stockpiles of atomic explosives (still being manufactured by the turn of the year at the rate of 6 6 lbs. per day) without waiting for the final devising of some perfect system of "effective safeguards." American trust in the UNO is the precondition of making the UNO trustworthy. In the wise words of Mr. Attlee to Commons last November: "Where there is no mutual confidence, no system will be effective."

Despite the long delay in constituting and convening the UN Commission, a vastly helpful blueprint is provided by the *Report on the International Control of Atomic Energy,* prepared by Chester I. Barnard, J. R. Oppenheimer, Charles

A. Thomas, Harry A. Winne, and David E. Lilienthal (Chairman) as consultants to the Secretary of State's Committee on Atomic Energy, consisting of Dean Acheson, Vannevar Bush, James B. Conant, Leslie R. Groves, and John T. McCloy. This report, released March 16, 1946, is a masterpiece of unanswerable logic which should be read and pondered by all citizens of the United States and of the United Nations. It distinguishes not between "peaceful" and "military" uses of atomic power but between "safe" and "dangerous" operations. The latter are defined as:

> Prospecting, mining and refining of uranium and, to a lesser extent, thorium, the enrichment of the isotope 235 by any methods now known to us; the operation of the various types of reactors for making plutonium, and of separation plants for extracting the plutonium; research and development in atomic explosives.

Such activities, as differentiated from medical use of radioactive tracers and the production of power and neutron sources from denatured U–235 and plutonium, are "dangerous" under any imaginable circumstances when left to national exploitation. The report therefore suggests the creation of a UN Atomic Development Authority which, under the direction of the Security Council, would own and operate throughout the world all uranium mines and all laboratories and manufacturing plants using fissionable materials in their dangerous form. It would also assume control of research and of all inspecting, licensing, and leasing functions designed to make impossible the manufacture of atomic bombs and to make available atomic power and its by-products for the good of all mankind.

No summary can do justice to these proposals, of which Professor I. I. Rabi rightly says in his preface that they have "no equal unless we go back to the annals which describe the origins of the basic law of this land." Suffice it to say that the program here offered is modeled on the Tennessee Valley Authority in the sense that it contemplates the establishment of a public corporation (in this case global rather than national) to own and operate all atomic energy plants and all sources of raw materials and to make "safe" products available for medical and industrial uses through lease or sale. TVA represents the most hopeful synthesis yet achieved between public economic planning and free business enterprise in a context which preserves the virtues of both and the vices of neither. A world ADA offers promise of effectively "outlawing" the bomb, of reconciling "national sovereignty" and "world government," and of bringing into being in functional terms the nucleus of a World State, limited at the outset to the most important single field of human endeavor in the atomic age. Such an agency would also promote a workable world-wide synthesis between "collectivism" and "individualism," thereby helping in the long perspective of coming years to bridge the chasm between the Soviet Union and the Atlantic democracies.

It is devoutly to be hoped that this plan will be made the official policy of the United States and the basis of the work of the UN Commission. The plan is adequate because it postulates that national governments will accept the superior authority of a world agency in this field and because it implies that the rules regulating the agency, as well as those issued by it, will in fact be a supreme law locally enforceable on individuals throughout the world.

E Pluribus Unum. If the cheerful assumptions may be made that Anglo-American-Soviet concord can somehow be restored and that global legislative authority over atomic energy can somehow be vested provisionally in the Security Council, then it becomes germane to

inquire as to what steps beyond this are needed to achieve the Parliament of Man and the Federation of the World. All reasonable citizens will agree with Secretary Byrnes (Charleston, November 16, 1945) that "we must not imagine wishfully that overnight there can arise fullgrown a world government wise and strong enough to protect all of us and tolerant and democratic enough to command our willing loyalty." What is called for is not a demand for Utopia nor yet a dismissal of all proposals for change as "Utopian," but immediate, constructive steps toward transforming the UNO into a workable federation. Ernest Bevin and Anthony Eden have expressed willingness to consider proposals in this direction. Official Washington, still in the grip of pride and prejudice, and official Moscow, still haunted by suspicion and fear, are both silent as these words are written.

If the creation of a world legislative authority in the limited but crucial field of atomic energy be regarded as the initial step toward replacing treaties by statutes in a gradually widening area of planetary policy-making, then attention must be given to devising a world legislature more adequate for its purposes, more democratic in its selection, and more federal in its structure than the Security Council can ever be. Ingenious proposals for complex schemes of representation are likely to prove acceptable and practicable in inverse ratio to their ingenuity and complexity. The long record of successful federal governments provides a formula of extreme simplicity.

With no important exceptions, all federations have reconciled the limited (but still real) sovereign equality of states with the efficacy of central agencies by the device of a bicameral legislature, in one chamber of which States (or Republics, Provinces, Cantons, etc.) have been represented in proportion to population and in the other chamber of which they have been represented as equals. Since federal legislation ordinarily requires a majority vote in each house, local rights, central authority, majority rule, and the sovereign equality of states are all effectively synthesized. In the community of nations an elective General Assembly, composed (purely by way of illustration) of one deputy for every 5,000,000 inhabitants or fraction thereof, would be a body in which America, Britain, the Soviet Union, France, and China would have, respectively, 28, 10, 38, 8, and 75 representatives for their metropolitan territories, with such states as Brazil, Mexico, Canada, Turkey, and Poland having from 3 to 9 delegates each. States the size of Australia, South Africa, Colombia, Greece, and Hungary would have 2 apiece, and all less populous states one each. To represent all states equally in an upper chamber or Security Council would create a body at once too cumbersome for its special functions and probably unacceptable to the Great Powers whose actual responsibility for the common defense and the general welfare is heaviest. It would therefore appear wise, at least provisionally, to retain the existing structure of the Council, with its five permanent seats and its six nonpermanent seats rotated among lesser states through election by the Assembly.

Irrational fears and hoary inhibitions would doubtless preclude any immediate general acceptance of the view that all legislation, within the carefully prescribed limits of the Federal Charter, should be enacted by a simple majority vote of both chambers. Some form of unanimity among the Great Powers and various safeguards for the lesser states would be needed to secure approval of the new dispensation. Ultimately, however, the familiar principle of majority rule (within a context of specified powers, constitutional prohibitions, division of powers, separation of powers, and

other "checks and balances") would commend itself to the good sense of mankind if it appeared that the provisional arrangements were working satisfactorily. Beyond this, the Security Council might well be extended into a more plausible facsimile of a democratic legislative chamber. A World Cabinet, responsible to one or the other or both chambers, might eventually come into being to perfect the structure.

Yet all such mechanical details would be incidental in a world which had once grasped and applied the precepts of federalism to its common problems. The great revolution, inaugurating a new era in world politics commensurate with the new problems of the atomic epoch, would find its central meaning elsewhere: first, in the enactment of world law not through contracts among diplomats representing sovereigns but through statutes passed by legislators representing the peoples and governments of the nations; and, secondly, in the enforcement of law not through promises and threats among sovereigns but through the adjudication of the rights and duties of individual plaintiffs and defendants in local, national, and international courts.

Large scale lawbreaking, requiring military action for its suppression, might still occur, regardless of whether the Union permitted or forbade secession. The members of the Union would be obliged, for their own safety, to require even a seceding state (assuming such a right were granted) to obey the law regarding atomic power, since any failure to do so, in the name of "nonintervention" and "respect for sovereign rights," would be potentially disastrous to all. Yet all necessary coercion would be directed not against states in their corporate capacity, but against groups of lawless and rebellious individuals who, in most imaginable instances, would be opposed by many of their own fellow-citizens as well as by the moral and physical power of the World Union. Even should insurrection assume widespread and persistent form, it would still lack the legal and psychological attributes of war, since the issue would lie not between states and states but between organized mankind and a group of outlaws. Atomic bombs would obviously never be used in such conflicts so long as the Union had a monopoly of their control, for the purpose of insuring obedience to law would be defeated by any weapon which indiscriminately annihilated the law-abiding along with the lawbreakers.

Once accepted, the federal principle, would, in Anthony Eden's phrase, "take the sting out of nationalism." All would be citizens of the World Republic as well as of their nation-states. None could plausibly practice the preachment of "My country, right or wrong!" Beyond this great divide, a broad vista of liberty under law would open out for all mankind, with innumerable possibilities of new political and social adventures in human betterment successively presenting themselves through the years to come. To speculate now upon these opportunities, however, would be a work of supererogation.

The Shadow of a Doubt. Only those with an indomitable faith in a beneficent providence or in man's rationality and capacity for self-fulfillment will be disposed to assume in the troubled dawn of 1946 that any such vision as has here been projected is likely of realization. Narrow is the road and strait is the gate into the promised land. *Homo sapiens* is a bewildered, fear-stricken, devil-ridden, and hate-filled caricature of a god and a beast. As Norman Cousins puts it, modern man is "obsolete"—or at least unable to live much longer in the company of his most cherished convictions and passionate prejudices. It may be, as H. G. Wells has argued, that the

species has already demonstrated its unfitness for survival. Those addicted to this entirely reasonable belief will dismiss all hopes as vain and all dreams as dust, certain to be lost in the endless darkness which will fall upon the world before another generation has reached middle age.

If universal fear becomes man's fate, as city after city leaps skyward in pillars of cloud by day and pillars of fire by night, some among the straggling survivors will no doubt remember in vain lament the words of Isaiah:

> The earth is defiled under the inhabitants thereof, because they have transgressed the laws, changed the ordinance, broken the everlasting covenant. Therefore hath the curse devoured the earth, and they that dwell therein are desolate; therefore the inhabitants of the earth are burned and few men left. . . . Fear, and the pit, and the snare, are upon thee, O inhabitant of the earth. . . . The earth shall reel to and fro like a drunkard, and shall be removed like a cottage; and the transgression thereof shall be heavy upon it; and it shall fall and not rise again. . . . Then the moon shall be confounded, and the sun ashamed. . . .

Without global government there will be no escape from annihilation. Before there can be global government, the UNO must be transformed into something adequate to the needs of the time. Before this transformation can proceed, a new harmony and a common resolve to serve shared purposes must be reaffirmed and translated into action by the leaders and the peoples of America, the British Commonwealth, and the Soviet Union. Toward this end there is little that Moscow can do save to practice forbearance, patience, and restraint. Its rulers know that any specific program they may urge will be met by many in the West with suspicion or contempt. Those who have unleashed the whirlwind have the duty of proposing the means of turning it to the ends of life rather than to the service of death. Responsibility lies with Britain and the United States.

Woodrow Wilson and Franklin D. Roosevelt, David Lloyd George and Winston Churchill, loom through the fog of days gone by as beacons of hope and courage in the annals of Anglo-American statesmanship. But there is little in the balance of the record to suggest that the rulers and voters of the Atlantic democracies possess in peacetime the qualities demanded by the imperatives of tomorrow: insight, foresight, imagination, and persistence in doing what is necessary rather than what is expedient.

The judgment of Dr. Herbert V. Evatt, Australian Foreign Minister, speaking in New York on November 27, 1945, may prove to be correct:

> It should be clearly understood that such a proposal (as world government) is quite impossible of acceptance. The plain fact is that the nations and peoples of the world are not yet prepared to surrender the rights of self-government in order to be governed by a central executive and a central legislature in which most of them would have a tiny and very insignificant representation.

In a time of testing, men may indeed turn back to the past while those upon whom the future depends may continue to fumble and fail. If not, a requiem must sound for the age-old ways which have always spelled chaos and now spell doom. If so, the bell will toll for all the achievements and aspirations of the great society which Western mankind has built through the centuries. In either case, the words of the ancient wise men, asked by their king for an aphorism appropriate to all possible occasions, will still hold true: "These things, too, will pass away."

THE LOST CAUSE

By Clarence R. Wylie, Jr.

Steadfast, my flesh, we dare not now grow soft;
We are too old to know a second spring,
And still in heart too young to bid farewell
To the bare mountains, and the woods, and streams
Where first we proved our manhood. Other lads
Can share these yet a while, for soon enough
Comes the dark day when sharing will be done
And what was wholly ours will pass to them.
To work, my flesh, the game is lost to us
But pleasant still to play.

We are the sturdy and strong of limb,
We are the brave and gay,
Breathless we stand at the golden bend
Where the bright years curve away.

No one believes us now, but we were strong
Beyond belief in those wild, wondrous days.
No challenge passed unheeded, and we proved
All things were possible by doing all.
Men tried to match us, and to each we gave
Choice of the game, and then in friendly bouts
Out-jumped, out-swam, out-fought the best of them.
And when in solitary paths we roved
Through our beloved wilderness, we found
In all our wanderings no crag too steep
To be our vantage point above the world,
Nor pack so heavy but we'd shoulder it alone
And take the portage at a trot.

Lean on the wind and embrace the storm,
Sail where the sea is white,
Shout out the cry of exultant youth
Through the clamor of the fight.

All now are dead who might remember us,
Dead in this life by wine, or wealth, or work
Unmixed with play, or just for want of faith.
Only as we remember does the past survive.
Oh, flesh, we dare not now grow soft,
We must not kill the brave, proud boy we were.

THE NATURAL HISTORY OF THE MUD SNAKE

By GEORGE P. MEADE
COLONIAL SUGARS COMPANY, GRAMERCY, LOUISIANA

THE mud snake *Farancia* is a large, brilliantly colored reptile (Fig. 1) with a sharp spine, or "horn," on the end of the tail, which is the basis of snake myths, superstitions, and unwarranted fears. The tail spine is not unique, however, as it is also present in some other snakes.

My own interest in the mud snake stems from a back-yard reptile collection in which *Farancia* has been the subject of special attention during the past 15 years. The mud snake is quite common in the region of Gramercy and about 150 specimens have been in my possession, all caught within a radius of 10 miles. A wire mesh cage with soft earth bottom partly covered with grass or leaves and properly shaded from the midday sun affords surroundings in which the snakes live and breed under conditions as nearly natural as is practicable in captivity. A large, shallow, galvanized iron pan provides sufficient water for their needs.

Besides the term mud snake, which is descriptive of the habits but not of the appearance, many fanciful names have been applied such as "stinging" snake, "horn" snake, and "red-bellied" snake. In this section of Louisiana the species is invariably referred to as the "stingaree," although this is the accepted common name of a fish, the sting ray. Among the French-speaking population the mud snake is *piquant queue.* The generic name *Farancia* is a coined word without significance. The genus has only one species *abacura,* and this name is from the Greek *abac* (checkered) and

Photo by D. Dwight Davis

FIG. 1. THE MUD SNAKE, *FARANCIA ABACURA*

SHOWING ITS CONFORMATION AND TAIL SPINE. (FROM SCHMIDT AND DAVIS, *Field Book of Snakes*).

FIG. 2. TWO SNAKE CHARMERS
LARGE MUD SNAKES ARE DOCILE AND USUALLY DO NOT RESENT HANDLING.

ura (tail), from the under-pattern of the tail.

The range of *Farancia* is roughly bounded by a line from Virginia through Missouri and thence to eastern Texas, although the distribution is not uniform throughout this area. Specimens have been taken in southern Indiana. The preferred habitat is swamps, muddy regions, ditch bottoms, or the shallow water at the edges of lakes. The climate and topography of southern Louisiana are ideal for this reptile.

Two subspecies, *Farancia abacura abacura* and *F. a. reinwardtii*, called the Eastern and Western mud snake, respectively, have recently been distinguished, but the two varieties are so nearly alike in gross characteristics that individuals can best be identified on the basis of the locality in which they are found. *F. a. abacura* occurs in the Atlantic Coast states and Florida; *reinwardtii* in Alabama, Louisiana, Texas, and the Mississippi Valley. All descriptions and observations given here apply to the Western subspecies *reinwardtii*.

The mud snake is the largest of the harmless species in southeastern Louisiana. The record specimen for my collection was 73 inches long with a diameter of nearly 2½ inches, and many examples over 66 inches long have been kept in captivity for extended periods. Large, well-fed captives are generally docile (Fig. 2), although the smaller ones frequently show evidence of nervousness by probing with the tail spine; by rapid convulsive jerking of head, or by hiding the head in a tight ball of

coils. Attempts to bite have never been seen or reported.

The coloration and pattern are extremely showy; the back shiny black from snout to tail tip with more than 50 brilliant red markings extending about halfway up the sides. The belly is of the same brilliant red with the black markings on the side extending into it to give a red-and-black checkered, or tessellated, effect which extends to the tail tip. Adding still further to the bright coloring are the yellow lip plates and chin scales, spotted with black, the yellow changing to orange as it shades into the red of the underbody. For a week or two before shedding the color is a light, translucent blue-gray, giving a ghostly appearance, and the snake is hardly recognizable as the same reptile by the layman. The effect is as if the snake had been dipped in a lead-colored lacquer, obscuring, but not entirely covering, the pattern beneath (Fig. 3).

The body of *Farancia* is cylindrical, the neck only slightly constricted, with the head flattened and tapering. The tongue is quite small, and the eyes are small, flat, and inconspicuous, indicative of the burrowing habits. Females are generally large and heavy-bodied, whereas the males are usually shorter and slenderer, with relatively longer tails than the females.

Until about 12 years ago little was known regarding the food of the mud snake. References in the literature mentioned frogs, mud eels, and salamanders as the probable food, and Ditmars reported feeding a few captive specimens on tadpoles; but keepers of zoos and private collectors reported to me that they had no success whatever in feeding this large and handsome reptile and most of them did not care to accept donations because of the certainty of starvation.

In April 1933 while on a collecting trip near Gramercy with a young friend, I saw a large mud snake swallowing one of the long eel-like amphibians *Amphiuma means tridactylum*, which are extremely common in this area. This amphibian has four vestigial feet and is known locally as the "lamp eel" and by the Negroes as "lamp-eater." Two specimens of *Farancia* were already in my collection, and when one of these "eels" was placed in a shallow pan of water and a 57-inch mud snake introduced with it, the mystery of the feeding habits was solved. The normally quiet, sluggish snake attacked with a speed and viciousness that were astonishing, and the struggle which followed was so violent that the two antagonists were thrown out of the water onto the ground.

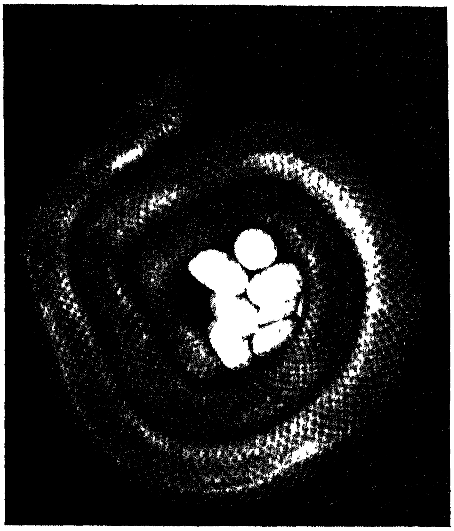

FIG. 3. A MOTHER SNAKE
PREPARING TO MOLT ONE MONTH AFTER LAYING.

This spectacular contest between the brilliantly colored snake and the gray, slimy amphibian has been repeated hundreds of times in my backyard (Fig. 4), and visitors are amazed at the extreme vigor of the snake's attack, which is in such sharp contrast to its seemingly docile and torpid nature. Noise or the presence of an excited audience, handling during feeding, or other disturbances do not distract the mud snake. No special feeding conditions are necessary, although shallow water or moist

ground has been found preferable as the slimy mud eel dries quickly in the absence of moisture and becomes sticky and hard to engulf. Among the many scores of these snakes that have been in my collection no specimen has persistently refused to feed during the summer months except, of course, during the pre-moulting period. On several occasions, large examples brought in from collection trips have fed immediately on being dumped out of the bag, and one 5-footer that had been tied securely with wire and carried in from the swamps on the end of a pole, seized a proffered amphibian promptly on release. Nevertheless, after a feeding great care must be exercised in handling the snake or it may disgorge either immediately or, worse yet, two or three days later when the food has been partly digested. *Farancia*, unlike most snakes, has to fight its prey, and veterans of many such feedings carry scars where their victims have bitten fiercely into the hide.

In order that they may breathe while swallowing large prey, many species of snakes are able to extend the windpipe beyond the front edge of the lower jaw, and this adaptation is particularly essential to *Farancia* because of the size and nature of the food. This protruding glottis, about the size and appearance of a piece of macaroni, may be seen in Figure 4 at the middle of the snake's under jaw. It is withdrawn and protruded as the snake needs air.

COMPLETE records of the breeding habits of snakes are comparatively rare since

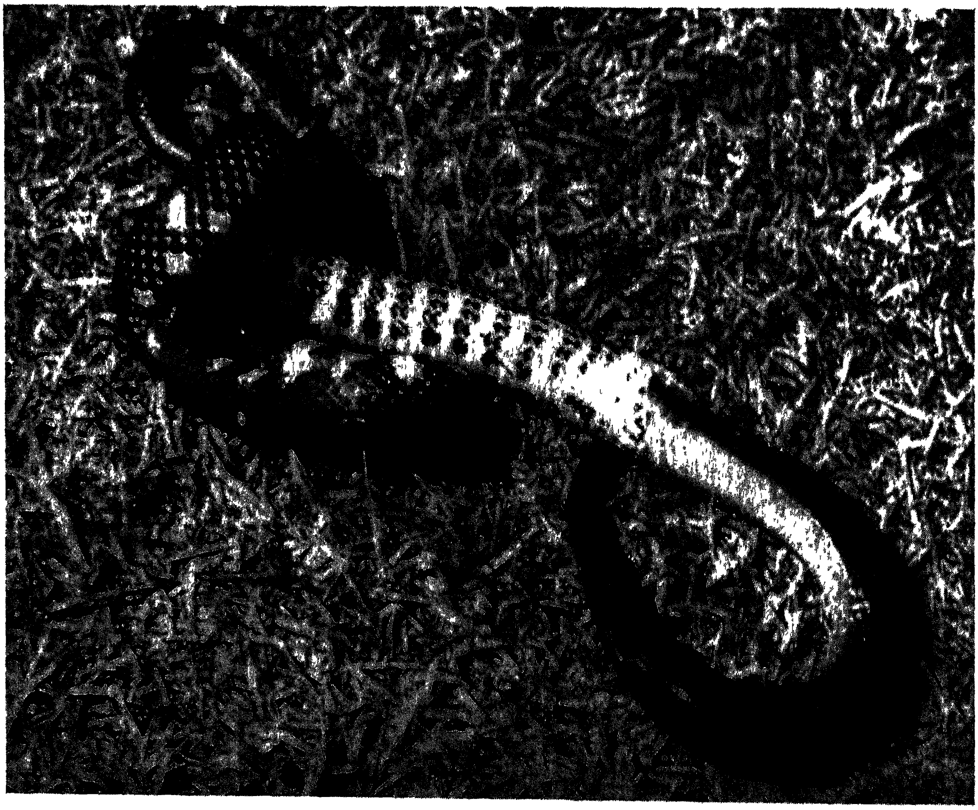

FIG. 4. *FARANCIA* FEEDING ON *AMPHIUMA*
THE GLOTTIS OF THE SNAKE MAY BE SEEN PROTRUDING AT THE CENTER OF THE LOWER JAW.

breeding in captivity is not usual and observation of such activities in the wild state is obviously difficult. The first recorded case of the breeding habits of *Farancia* was that of a 67-inch female in my collection that had been in captivity more than a year and a recently caught male, only 42 inches long and weighing 1 lb. 10 ozs., less than one-third the weight of the female. The mating took place on July 11, 1936, and 28 eggs were laid on September 5, just 8 weeks later. They were cream-white, smooth, nonadherent to one another, and quite regular in size and shape, varying in the shorter diameter from 21 to 24 mm. and in the longer from 42 to 48 mm. As in all snake eggs, the shells were tough, flexible, and leathery. As will be seen in Figure 5, the snake attempted to keep the eggs within the coils of her body.

These eggs were incubated in bagasse, the residue from the grinding of sugar cane, that had been dried and sterilized for sale as litter for small chickens. The material, which is absorbent and clean, was kept moist by sprinkling it every few days. (It has since been found that snake eggs are much more readily incubated in a tightly closed glass jar, with a moist cloth on the bottom on which the eggs are placed, permitting observation throughout the incubation period.) Snake eggs "grow" during incubation by absorbing moisture, and after 7 weeks, these were almost the size of small chicken eggs. Nineteen of the eggs hatched on October 30 and 31, 8 weeks after laying and 16 weeks from the mating date.

The young were quite slender and smaller than had been expected, averaging about 8 inches in length. In conformation and pattern they were strikingly similar to the parents, black above, checkered black and red below, with the tail tip equipped with a needle-sharp spine. The yellow color of the chin and lip plates, which was pronounced in the male parent, was entirely absent. The brood were lively and active, burrowing briskly into the moist bagasse in which they were hatched. They never attempted to strike or bite but when handled would first show the bright pattern under the tail and then stab ineffectively with the diminutive spine. During the first week they went through the characteristic color changes of mature specimens before molting, and on the seventh day they all shed their skins.

Seven other clutches of eggs that have been recorded in Gramercy had from 15 to 30 eggs per clutch, and all were laid a month to 6 weeks earlier than the lot described above. The earliest laying date was July 14, the latest August 13. Hatching of these various sets of eggs occurred between September 15 and October 4, the period of incubation varying from 7 to 9 weeks. From these data it would appear that in this region *Farancia* generally lays from 20 to 30 eggs in late July or early August and that hatching occurs late in September or early in October.

Conclusive evidence is accumulating that the mud snake takes care of her eggs, although many books and treatises erroneously state that no maternal care is shown by any snake except the python. The photograph (Fig. 5) of the egg laying described above shows the position of the mother after the deposition of the last egg. It seemed evident that an attempt was being made by the snake to keep the eggs within the coils of her body, but whether this was for the purpose of incubating them or merely to hold them in a close group could not be determined. The eggs were removed from the mother immediately and incubated artificially, with the results previously described.

The first direct evidence of maternal care was observed in the summer of 1939. On August 10 a 52-inch female was found in one corner of the cage, coiled around 18 eggs somewhat more closely than in the previously observed instance.

Photo by Henry G. Gerstner

FIG. 5. *FARANCIA* JUST AFTER LAYING

All other snakes were removed, and the mother and eggs were protected from the sun and rain by inverting over them a large, shallow, galvanized iron pan with the edge raised to permit exit and entrance. During the first 6 days the snake changed her position slightly, pulling the clutch more closely together and covering the outer eggs more fully with the coils of her body.

On the sixth morning the snake was found at the opposite end of the cage, and the egg group was somewhat scattered. It was feared that the maternal interest in the eggs was at an end, so half of the clutch was removed and incubated artificially. The other 9 eggs were left on the floor of the cage and the pan inverted over them as before. When the mother was found tightly coiled about the eggs on the following morning there was little doubt of her intent.

During the next 6 weeks the mother left the eggs twice to shed her skin, 4 times to defecate, and was removed from the cage 4 times to feed on *Amphiuma*. It is significant that the shedding and defecation were done at the far end of the cage from the eggs, since cast skins attract ants almost immediately in this climate and the excreta is voluminous following heavy feedings. During the incubating period the snake did not resent handling, offered no objection to being removed from the eggs, and did not appear nervous or disturbed. She did not seem anxious to return to the eggs when away from them but later would be found coiled closely around them in the manner shown in Figure 3.

The 9 eggs artificially incubated all hatched on September 28, 7 weeks after laying. The next day a torrential rain flooded the cage where the mother snake was tending the rest of the clutch, so the

eggs were removed and placed in an incubating jar where they hatched the following week. The young were similar to those of the first brood.

As a coincidence, while the above study was in progress a letter from Philip D. Evans, of Kansas City, reported that a farmer in Dinkler County, Mo., claimed to have killed a large "stinging snake" under a board near a drainage ditch, and that the snake was coiled around a clutch of about 15 eggs. Evans secured some of these eggs and these hatched about 2 weeks later, which "would suggest that this species in some cases does remain with the eggs." Another instance was observed by Goldstein in Florida in which a 6-foot specimen of *F. a. abacura* was found on August 21 coiled in a hole in the side of a mound. Embedded in the walls of this excavation in 3 successive rows or layers were 40 eggs, with the inner eggs partly protruding from the sides of the wall. From examinations of various eggs that were opened, Goldstein concluded: ". . . that the female had stayed with them for some time." He found a *Farancia* cast skin nearby, "probably from our female specimen."

More striking evidence of maternal care was observed in the summer of 1944. A 5-foot specimen of *reinwardtii* laid 22 eggs on July 14 in the same open cage and remained coiled about them. The procedure of covering snake and eggs with a moist cotton sugar sack and then with the inverted galvanized pan was followed. The next day when the pan was lifted for observation the eggs were completely covered by the cloth, with the snake coiled on top of its outside edges. The effect was that of a cloth hat with the eggs under the crown and the snake resting on the brim. The shaping of the cloth and consequent covering of the eggs could not have been achieved more accurately by hand. As before, the snake was removed 3 times to feed on *Amphiuma*, and molting and defecation were effected as far from the eggs as the cage would permit. Each time the snake would return, generally during the night, to coil about the cloth-covered eggs. On August 18 the cage was flooded with rain and the eggs dispersed. The snake appeared to lose all interest in them, so they were removed and placed in a jar for artificial incubation; two hatched on September 20.

A noteworthy point is that, so long as the mother snake remained coiled about the eggs, there was no evidence of attack by mildew, ants, or maggots, yet eggs artificially incubated here must be carefully protected from these three destructive agencies. Whether or not the presence of the mother has some protective value is a matter for conjecture.

The spine on the end of the tail is a hard, hornlike terminal scale that has been the subject of much comment and speculation, both scientific and otherwise. Among laymen, it is thought to be poisonous, and the ignorant are positive that it is a deadly "stinger" capable of killing not only human beings and animals but also trees. Lumbermen and trappers working in the nearby swamps have been found to be much more afraid of the sting than of the bite of a rattlesnake or cottonmouth. A common belief, expressed in some early descriptions of the species, is that the spine is retractible and can be "darted in and out."

Various suggestions have been made in the scientific literature as to the function of the tail spine, but none of these has been the result of extended observation. The commonest idea is that of protection, because many specimens when picked up or restrained prod the hand with the tail, in rare cases to the extent of drawing blood. Even hatchlings, as previously pointed out, stab with their diminutive tails. Another suggested use is that the tail spine serves to hold the slimy prey during feeding, but in the several hundred feedings that I have

witnessed no such use has ever been observed. One authority states that "it probably functions during burrowing," and others have suggested that the sharp tail is driven into the ground when the snake is struggling with *Amphiuma* or dragging the amphibian out of a hole; but again no such action has ever been noted either in my captive specimens or in snakes in the wild state.

The bluntness of the spine in mature examples is evident. Curious observers are disappointed to find the famous "horn," or "sting," of a large mud snake no sharper than a blunt pencil point, although that of smaller specimens is generally sharp. This difference seems to have some significance, as it has been repeatedly observed that the younger or smaller specimens use the sharp spine as a goad when the amphibian prey bites and holds onto the snake. Under these circumstances, particularly when seized near the head, the snake stabs the victim so sharply with the spine as to cause it to release its hold. Blood is frequently drawn, and long deep scratches are inflicted on the soft body of the amphibian. Large *Farancia* have sufficient bodily strength to break the hold without the use of the spine. It is of interest that this species has exceptionally strong jaws, far stronger than those of most snakes.

The story of the snake that takes its tail in its mouth and rolls like a hoop is persistent. Most authorities say that this myth is commonly identified with the mud snake and indicate that the possession of the tail spine is in some way related to the hoop story. Ditmars suggests that a possible explanation is the "habit of *Farancia* of occasionally lying in a loose coil . . . almost forming a circle" and having the appearance of "a discarded bicycle tire." A much more definite basis for the hoop-snake myth may be seen while *Farancia* feeds on *Amphiuma*. The larger snakes, especially, have a habit of rotating on their longitudinal axis when they are in a position to start engulfing the prey; that is, when the jaws have grasped either the head or tail of the victim. This rotation is frequently so rapid as to suggest that snake and victim are driven by a pulley, and the brilliant pattern of the snake is blurred by the motion. In the course of this peculiar axial rotary maneuver, the struggling pair have been seen to form almost a complete circle, and the rotation then carries them along the ground still in the circle or hoop and still revolving about the curved axis of the snake. Colored moving pictures of this phenomenon invariably bring forth the comment, "There's the hoop snake."

The picture of the first feeding ever observed (Fig. 6) shows this hooplike position of the pair. In this instance, the amphibian is being swallowed tail first, so that its mouth might easily have grasped the tail of its captor. If this had occurred (I have never seen it happen) and the axial rotary motion had proceeded, the illusion of a revolving hoop would have been even more vivid. Whether this complete circle has ever been observed or not, there seems little doubt that the rapidly rotating near-circle must have been seen many times during feedings in the wild state, affording ample basis for the hoop-snake story in the southern lowlands.

One of the few reported studies of hibernation of snakes was made at Gramercy on a 65-inch *Farancia*, that weighed 3 lbs. 11 ozs. on October 24, 1934. On November 4 it was placed on a layer of mud at the bottom of a packing box sunk in a hole near a small pond, the bottom of the box being at the water level and the top covered with wire mesh. The snake did not appear until mid-February, remaining above ground for several hours. Its weight on March 6 was found to be 3 lbs. 10 ozs., only 1 ounce less than the weight over 4 months before. On successive appearances *Amphiuma* was refused in spite of the long fast,

FIG. 6. A HOOP SNAKE?
Farancia TAKES A HOOPLIKE POSITION WHILE ENGULFING *Amphiuma*. X MARKS SNAKE'S HEAD.

but on March 26, nearly half a year from the last feeding, the snake was finally removed from the box, and a small amphibian was taken. The snake appeared to be in excellent condition, no more sluggish than usual, and tongue motions were frequent.

Experience has since shown that hibernation in captivity requires no such elaborate preparations. A few bushels of dead leaves or grass placed in the outdoor cages and loosely covered with tar paper afford the shelter desired by nearly all the species in my collection.

The twin plagues of the snake collector, mouth-rot and mites, have never appeared in my specimens of *Farancia*. Two conditions that have been fairly frequent are white water blisters on the skin and some sort of white growth (fungus?) that affects the eyes. The water blisters seem to be caused by excessive moisture because they disappear after shedding if the snake is removed to a dry cage before the trouble has become too prevalent. A few blisters have been cured by washing with a mild antiseptic, but if the blisters are very extensive the snake is released.

The eye condition first appears as a whitening of one or both eyes and may possibly be started by failure of the eye plates to shed. The eye becomes distended until it is the size of a pea, completely opaque, and seemingly ready to burst. No treatment here has been successful, although Karl Kauffeld, of the Staten Island Zoo, reported some success with dilute potassium permanganate.

Very little has been learned of the rate of growth of mud snakes either in captivity or in the wild state, though this would certainly be an interesting study if regular food supply could be assured. The feeding habits of freshly hatched specimens have never been demonstrated. Goldstein reported that earthworms were taken, but none of the hatchlings at Gramercy ever showed any interest in such food. They probably eat hatchling *Amphiumae*, which are extremely plentiful here in early spring. One zoo keeper reported that small *Farancia* fed readily on strips of flesh cut from a large *Amphiuma*, but no young have been at hand since this information was received.

Another unsolved problem is whether maternal care of eggs in the wild state is the rule. The observations of Goldstein and Evans and the less reliable reports from local lumbermen, together with the evidence of care in captivity, are convincing but not absolutely conclusive. If these reported cases are not isolated instances the question remains, Why does the mud snake brood or incubate the eggs when other snakes of similar habitat find this unnecessary? Richmond reports no indication of such care in the rainbow snake *Abastor*, which resembles *Farancia* in many habits and characteristics.

COLOR PHOTOMICROGRAPHY

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SUCCESSFUL photomicrographs are assured only when the principles of good microscopy and critical illumination are adhered to. Owing to the characteristics of present materials for black-and-white photography, errors in adjustment of the optical system, character of the light source, and variation in exposure may never be revealed in the finished print. The color films, on the other hand, do not possess the latitude of the black-and-white negative materials. This means that careful adjustment of the optical system and correct exposure are essential. In addition, the color films pose a further problem in the matter of the quality of light to which they are exposed.

Without proper concern for the requirements of the color film and reasonable familiarity with the principles of illumination for the microscope, attempts to produce photomicrographs in color are certain to be disappointing.

The Camera. In general, the requirements for a camera in color photomicrography are not different from those for work in black and white. Probably the most nearly universal type of camera consists of a light-tight, adjustable bellows, capable of being extended at least 10 inches, with interchangeable focusing screen and negative holder at the back and a means for making a light-tight coupling between the front board and the microscope eyepiece tube.

Owing to the higher cost of color films in professional sizes and the popularity of the 35 mm. roll film for record purposes, the photomicrographic camera can be simply one of the small cameras designed to handle this type of film.

It is not advisable to project the image from the microscope eyepiece directly to the film with a projection distance less than 10 inches, especially with objectives of short focal length. Therefore, in the event it is desired to use a miniature camera directly over the eyepiece of the microscope, the regular camera lens should be left in place and focused for infinity. The microscope should be focused to project a real image of the specimen at a considerable distance (several feet) from the eyepiece, and the camera then carefully positioned over the microscope eyepiece without changing the focus of the microscope.

The Microscope. The microscope stand should be a good professional model, preferably fitted with a corrected substage condenser. For the best results with color, especially at the higher magnifications, the apochromatic or fluorite (semi-apochromatic) objectives are desirable. The compensating type of eyepiece should be used with these objectives. Achromatic objectives and the Huygenian eyepieces are satisfactory at lower powers and in some cases may prove adequate in medium and high-power ranges.

A substage iris diaphragm is an important adjunct if properly used, for by its means it is possible to exercise an appreciable control over contrast and depth of focus.

While referring to the substage equipment of the microscope, it might be mentioned that a device employed by the earlier microscopists, but apparently little used today, can be an aid to color photomicrography; that is, the use of a microscope objective as a substage condenser. The present substage condensers have been designed to work with the full range of microscope objectives used on a

particular stand, especially the corrected forms which are made divisible so that separate elements are suitable for certain objectives. Since the focal lengths are long with respect to their numerical aperture, the condensers do not carry the high degree of correction incorporated in the objective. At the lower powers where the working distance of an objective is sufficient to work through the specimen slide, excellent results are obtained by using an achromatic objective as the substage condenser. Most research-type microscopes are supplied with an adapter for using an objective in the substage. The numerical aperture and focal length of the objective in the substage should be at least very nearly that of the objective above the specimen slide. The difficulty with this arrangement, of course, arises with the higher power objectives because the working distance becomes so short that specimens must be mounted between cover glasses rather than on the conventional specimen slide.

The Light Source. For critical microscopy and photomicrography it is desirable that the light source be homogeneous and of concentrated form. The effectual source in most systems of critical illumination is approximately 3 mm. in diameter. Appropriate lamps affording a source of this size are the 6-volt, 18-ampere ribbon filament lamps and the carbon arc lamp using electrodes 5 to 8 mm. in diameter. In the majority of incandescent tungsten lamps with clear envelopes and coiled filaments, the filament arrangement does not provide the homogeneity desirable for microscope illumination. Although lamps of this type and the inside-frosted lamps with rather large envelopes are not directly applicable as sources, on occasion it may be desirable to use one of these types. The method of applying them will be described later.

The complete illuminating unit should consist of a housing for the lamp and a condensing lens of the correct focal length to form an image of the light source about 30 mm. across its smallest dimension at a distance of 10 to 20 inches. It is desirable that the condenser consist of an arrangement of spherical lenses or an aspheric lens to provide a degree of correction for spherical aberration. Typical illuminating units suitable for color work are the Bausch & Lomb Research Microscope Lamp incorporating the ribbon filament or the illuminating units as supplied with the Bausch & Lomb Photomicrographic Apparatus.

An iris diaphragm directly in front of the lamp condenser is a distinct advantage, though not essential. Besides aiding in the alignment of the system, it provides a definite control for the size of the illuminated field.

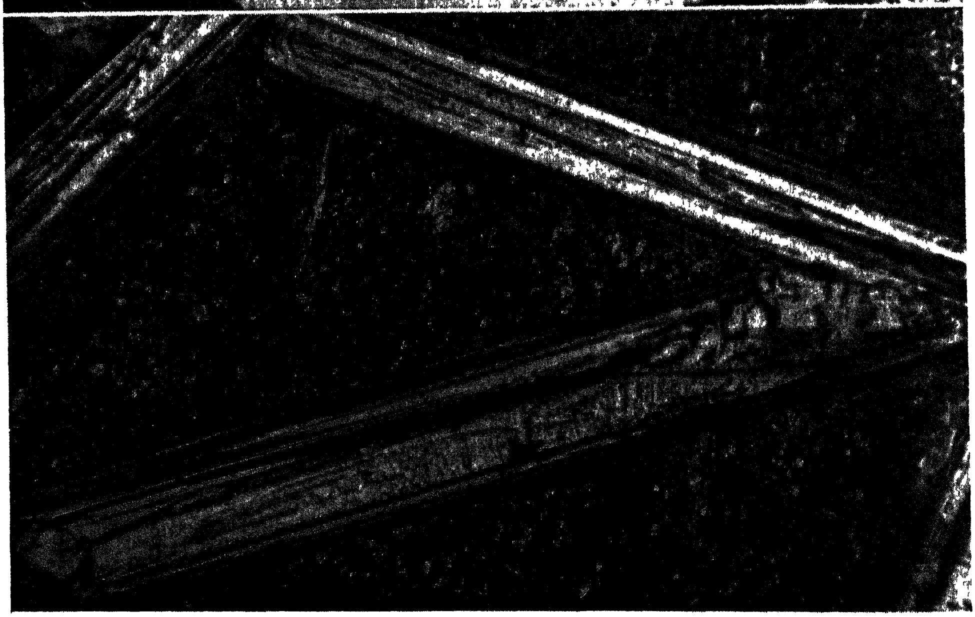
Light sources having a discontinuous spectrum, such as gaseous discharge tubes, or a combination of line spectrum and continuous spectrum (as is the case with the mercury-tungsten arc lamp) are not suitable for color work.

Color Films and Their Relation to the Light Source. Two types of film are available in both Kodachrome and Ansco Color. That for use in light of daylight quality is adjusted to a color temperature in the range of 5,400° to 6,000° K. The films for use with artificial light sources are adjusted to particular incandescent tungsten lamps designed to provide a definite color temperature at particular operating voltages. For obvious reasons, the tungsten type films are most generally used in photomicrography.

Kodachrome, Type B, is adjusted to a color temperature of 3,200° K. to match the color temperature of a series of 3,200° K. lamps manufactured by the General Electric Company. The popular 35 mm., Type A, roll film, however, is adjusted to a color temperature of 3,450° K., matching the color temperature of the familiar

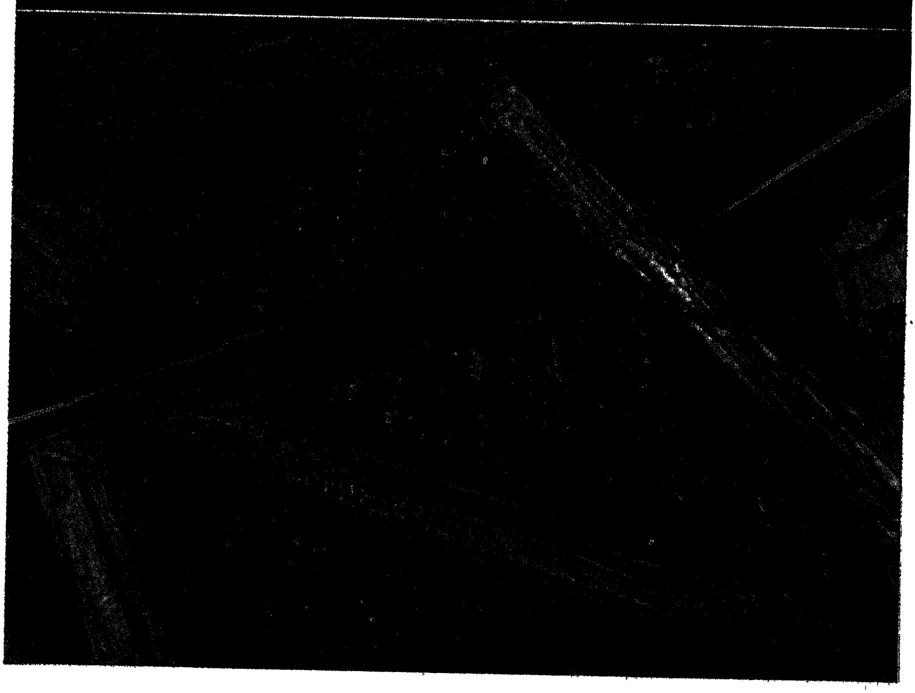
TARTARIC ACID CRYSTALS

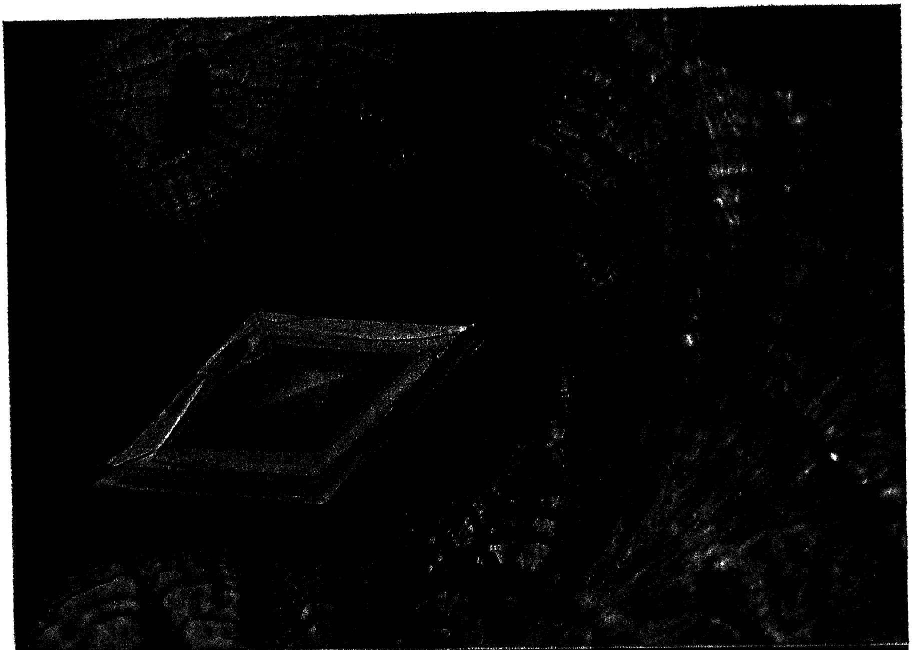
OBTAINED BY ACCELERATED EVAPORATION OF A CONCENTRATED SOLUTION IN THE PRESENCE OF GELATINE. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 10 ×; OBJECTIVE, 32 MM. MICRO TESSAR F: 4.5; EXPOSURE, 1 SEC.; FILM, ANSCO COLOR, TUNGSTEN TYPE, SHEET. COLOR PLATES FROM THE BAUSCH AND LOMB OPTICAL CO.



AMMONIUM SULPHATE CRYSTALS

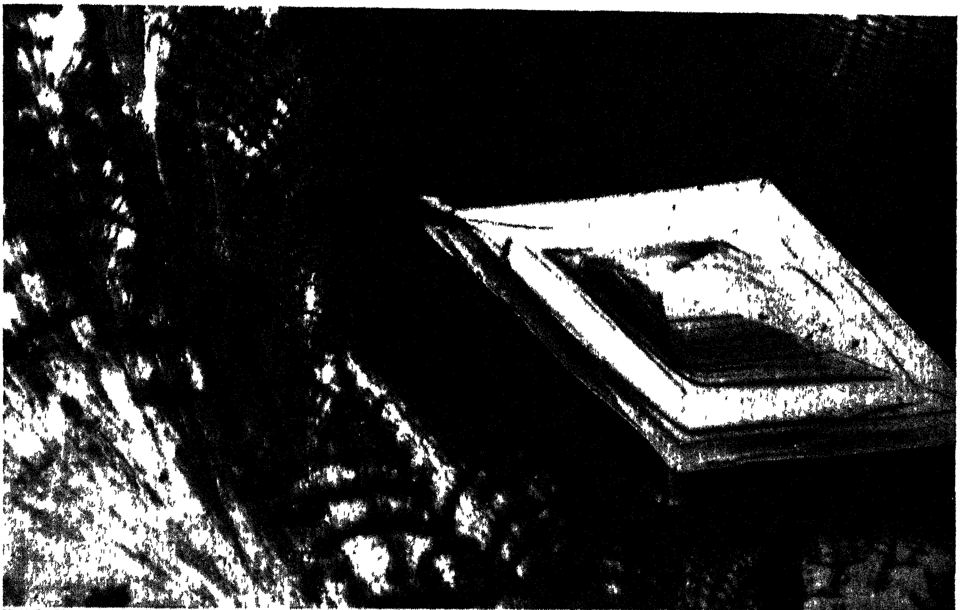
OBTAINED BY RETARDED EVAPORATION OF A CONCENTRATED SOLUTION AT ROOM TEMPERATURE. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 75 ×; OBJECTIVE, 22.7 MM. 0.17 N.A. ACHROMATIC; EYEPIECE, 5 × HYPERPLANE; EXPOSURE, 2 SEC.; FILM, ANSCO COLOR, TUNGSTEN TYPE, SHEET. COURTESY B. & L. OPTICAL CO.





ASPARAGINE CRYSTALS

OBTAINED BY RETARDED EVAPORATION OF A CONCENTRATED SOLUTION. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 80 ×; OBJECTIVE, 22.7 MM. 0.17 N.A. ACHROMATIC; EYEPIECE, 5 × HYPERPLANE; EXPOSURE, 2 SEC.; FILM, ANSCO COLOR, TUNGSTEN TYPE, SHEET. COLOR PLATES SUPPLIED BY THE BAUSCH AND LOMB OPTICAL COMPANY.



SALICINE CRYSTALS

OBTAINED BY RETARDED EVAPORATION OF A CONCENTRATED SOLUTION AT ROOM TEMPERATURE. THIS IS THE MIRROR IMAGE OF THE ADJACENT COLOR PHOTOGRAPH TO WHICH THE FOLLOWING DATA APPLY: MAGNIFICATION, 30 ×; OBJECTIVE, 22.7 MM. 0.17 N.A. ACHROMATIC; EYEPIECE, 5 × HYPERPLANE; EXPOSURE, 1 SEC.; FILM, KODACHROME, TYPE B. COLOR PLATES FROM THE BAUSCH AND LOMB OPTICAL CO.

photoflood lamps. In the case of Ansco Color Film, both the professional film and the roll films are adjusted to 3,200° K. The choice of the size of film to be used will be influenced by the type and quantity of work to be done, the form of camera employed, and perhaps by the light source at hand.

Although the carbon arc lamps designed for use in photomicrography and the 6-volt, 18-ampere ribbon filament lamps are excellent light sources with respect to source size, their color temperatures do not coincide with the color temperature requirements of the color films. It is necessary, therefore, to alter the quality of the light from these sources.

The matter of adjusting the color temperature of the carbon arc lamp is complicated somewhat by the presence of excessive ultraviolet in its spectrum. To adjust the color temperature of the arc it is necessary first to introduce a filter to remove the excessive ultraviolet. Since the color temperature of the arc is somewhat above the 3,200° or 3,450° K. rating for the tungsten type films, it is then necessary to introduce filters to reduce the effective color temperature of the visual light transmitted by the U.V. filter. The U.V. filter can be made up in liquid form and placed in the water cell normally used for heat absorbing purposes, so that the solution performs the two functions at once.

The 6-volt, 18-ampere ribbon filament lamp operates at a color temperature in the range of 2,800° to 3,000° K. With a ribbon filament lamp operating at normal voltage, a Wratten 78 C filter placed in front of the lamp condenser will in many cases provide an effective color temperature sufficiently near 3,200° K. to give very satisfactory results with Type B Kodachrome or Tungsten Type Ansco Color Film.

To determine the effective color temperature with a sufficient degree of accuracy, a device such as the color temperature meter made by the Eastman Kodak Company and described by Lowry and Weaver[1] should be employed. With such a device it is possible to operate the lamp at a reduced voltage and select a suitable filter to provide the required color temperature. Matching of sources and film is discussed by Loveland.[2, 3]

When using photoflood lamps as a light source with type A Kodachrome, the need for photometric filters is eliminated. To use one of these lamps and to obtain the effect of a small source, the procedure is as follows:

A sheet of ground glass is mounted in front of the lamp to afford adequate diffusion. A light shield is then prepared by punching a hole 3 to 5 mm. in diameter in a piece of sheet metal. The shield is mounted in front of the ground glass, and the condenser lens mounted in front of the aperture in the shield. The light shield should be placed very close to the ground glass. A housing should be placed around the lamp; however, it must be constructed so as to permit adequate ventilation for the lamp. The condenser lens should have a focal length on the order of 30 to 60 mm. for convenience and should have a relative aperture of about f : 1.0. The illuminating unit should be capable of projecting an image of the small aperture about 30 mm. in diameter at a distance of 12 inches or more from the condenser lens.

Alignment of the Optical System. In order to produce satisfactory photomicrographs in either black and white or color it is essential that the optical system be properly aligned and that the requirements for critical illumination in the microscope be met.

In practice, the Köhler form of critical illumination is generally used. In this system the condenser lens of the illuminant is focused to project an image of the light source into the opening of the substage condenser lens. The distance from the illuminant to the microscope substage must be great enough so that the projected image of the source will

completely fill the maximum opening of the substage condenser. The substage condenser in turn is then focused by means of its rack-and-pinion adjustment to form an image of the lamp condenser directly on the specimen.[4, 5, 6] During this adjustment the iris diaphragm of the substage condenser should be fully open. The plane side of the mirror should be used to reflect the light beam into the substage condenser if the microscope is in the vertical position.

With the proper substage condenser in the microscope the image of the lamp condenser formed on the specimen plane should be large enough to fill the field included by a given eyepiece and objective combination.

The camera should be so supported that it centers over the microscope eyepiece and so that the plane of the film or focusing screen is perpendicular to the axis of the microscope. If a lens is incorporated in the camera, the lens should be located close to the microscope eyepiece. The narrowest point in the light beam emerging from the eyepiece (the Ramsden disc) should be located at the plane of the iris diaphragm of the camera lens if possible.

Color Compensation. Because of the somewhat complicated optical system involved in the photomicrographic system incorporating a microscope, the light reaching the color film in some cases may not be of the identical quality as that leaving the illuminating unit, even though color temperature adjustments have been made at the source. The color imbalance may be caused by selective absorption of certain colors by the optics in the system. A filtering action may also occur in the specimen-mounting medium. Lack of chromatic correction in the substage condenser in the microscope or incorrect focusing of this element may also introduce false color. This color effect may not become troublesome except at the higher powers, and even then it may not be considered sufficiently serious to warrant corrective measures. The condition will vary from one setup to another, and no one system can be employed to remedy all cases. Deficiencies in the light reaching the color film can be corrected, if desired, by introducing special color filter solutions prepared by Eastman Kodak Company.[2, 3]

At the lower powers, up to 100 X or so, and when photographing specimens such as those illustrated here, it is doubtful if such color compensation is actually necessary. No color compensation was found necessary when the originals of the accompanying illustrations were made.

Exposure. Methods have been described whereby photoelectric exposure meters or visual photometers are used to determine the correct exposure time for the color films.[7, 8] Such devices, if carefully used, are convenient and will give accurate determinations, provided the quality of light and illumination conditions in general have been correctly adjusted for the particular color film. In the event some form of photometer cannot be used, the correct exposure time can be determined photographically by first making trial exposures on black-and-white materials and then calculating the exposure time for the color film from the known speeds of the two materials.

Theoretically, the black-and-white material used for making such exposure tests should be of the reversal type.[7] However, in determining the exposure for the originals of the accompanying illustrations, ordinary negative materials were employed. The illustrations presented here were selected from a series of color photomicrographs including stained sections as well as chemical crystals in polarized light. Type B Kodachrome and the professional Ansco Color Sheet films were both used in making the complete series. Lacking other means of exposure determination, it was decided to try the exposure test

method with black-and-white negative material, choosing the exposure giving a good range of tone when the negative was developed in a normal manner.

The negative material used for making the exposure tests included both Eastman Panatomic X and Defender Fine Grain Panchromatic Films. The Wratten X–1 filter was placed in the illuminating beam when the trial exposures were made. The negatives were processed in Kodak formula DK–60-A developer for 4 minutes at 20° C. Previous to exposing each color film an exposure test strip was made on the negative material. From this test strip the exposure judged to be correct was chosen. A full-size negative including a large portion of the specimen was then exposed and developed to provide a better over-all judgment of the exposure. The ratio of the recommended Weston speed numbers for the negative and color material was then applied to determine the exposure for the color film. At the outset 3 color films were exposed per specimen, using the estimated time and exposures 25 to 50 percent shorter and longer. The color films were returned to the manufacturer for processing.

The finished transparencies were compared with the original specimen projected onto the camera ground glass when possible to do so. It was found that the exposures determined by the method described produced satisfactory results, and the practice of including the longer and shorter exposures was discontinued with subsequent films.

It should not be concluded that this method of exposure determination is presented as an approved and certain procedure. As indicated earlier, the method is contrary to theory. However, the results obtained were entirely satisfactory and the method apparently is applicable in the event approved methods[7] cannot be employed.

The photomicrographs presented here were taken on the large Bausch & Lomb Photomicrographic Equipment. The originals were made on 5×7 film. No color compensation was employed. A 78 C filter was used to correct the color temperature of the light source to 3,200° K.

Polaroid discs were used as the polarizing elements. One at the illuminator, directly in front of the Wratten 78 C filter, acted as the polarizer, and the other above the eyepiece (immediately behind the Micro Tessar in the case of the Tartaric Acid illustration), as the analyzer. A first order red retardation plate was held between the analyzer and the microscope eyepiece. The polarizing elements were rotated to produce the most vivid and striking colors.

The specimens were all prepared without cover glasses. In the case of specimens mounted with cover glasses, it is advisable to use a colorless mounting medium if possible. Furthermore, when an oil immersion objective must be used, a colorless immersion oil is recommended. The use of these materials will help to reduce the problem of color compensation.

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"BIOLOGICAL ABSTRACTS"

By STANLEY TRUMAN BROOKS

THE spread of Christianity and the pursuit of scientific knowledge were the first two fields of human endeavor to realize the global aspect of their labors. In nations politically isolationist and narrow in their humanitarian efforts, students of science found that only through cooperation with their fellow students could man progress. This early united nations' effort weathered wars, disasters, the rise and fall of kingdoms, and the economic fluctuations of a growing world. Science, as does Christianity, was found to transcend all barriers—to embrace all races, all colors, all creeds.

Strange as it may seem to the peace-loving student *Biological Abstracts,* the world's largest abstracting service to the biological sciences, was born of the confusion and catastrophic scenes of World War I. Prior to that time the American and European student depended largely upon the German abstracting organizations for knowledge of their co-workers' advances and discoveries. Naturally, therefore, when that early Axis rent asunder the channels of information, America was truly isolated from all the scientific knowledge of over half of the world. This condition stirred the students of America to discuss their predicament and to take steps to mitigate their circumstances.[1]

As a result, in 1922 there gathered in Washington the appointed representatives of 19 national biological societies who, with similar groups from the National Research Council and the American Association for the Advancement of Science, conceived and dedicated the institution which became the international *Biological Abstracts* in 1926.

Scope of the Field. No one can say what the scope of the field was 20 years ago when *Biological Abstracts* came into existence, and even today, with all the developments in transportation and communication, obscure publications of some years' standing are only now being discovered by American and European students.

One can safely judge, however, that there were probably some 50,000 printed articles describing and reporting biological research each year as well as the issue of several thousands of books. These articles were printed in possibly 30 languages and in the majority of cases were confined in their distribution to their own geographical areas; only a small proportion of this world-wide literature was available in a few of the larger libraries of each country.

At the outbreak of World War II there were at least 6,000 research periodicals and journals containing some 60 to 70 thousand articles annually.

Because of this tremendous volume of research and because of the language barriers, no investigator could keep himself abreast of his own field unless he had access to the knowledge in abridged form. No library in the world is large enough to contain all this annual accumulation of knowledge, or if there were one of that size it would be unavailable to most students.

With the end of World War II there have been some fatalities among the research journals of the world, but these eliminations are far outnumbered by the increase in publications in the newer fields of research stimulated by wartime

[1] *Abstracts of Bacteriology*—1917; *Botanical Abstracts*—1918. These first abstracting groups merged with *Biological Abstracts* in 1926.

needs. Even in some of the European countries, overrun and despoiled by Hitler and his armed hordes, new publications are appearing, and announcements have been made to *Biological Abstracts* that research which progressed even under the shadow of the Gestapo has been preserved and results will now be published. Chinese publications are planning to resume, and scientific life stirs anew in all Asia.

The Philosophy of Biological Abstracts. Abstracts are a means of mobilizing man's knowledge. Perhaps the greatest impediment to the advancement of science today is the lack of effective means by which the findings of the scientists of all nations can be mobilized, brought to the attention of students, and put to work for humanity. The philosophy is purely one for human advance and is therefore universal.

The abstracting journal is perhaps the only method by which the student today can compensate for the deficiencies of research libraries. With the exception of a few major institutions, the biological libraries of our colleges, universities, and research organizations are pitifully inadequate. Capable students are being handicapped over all the world with a resultant inestimable loss to mankind.

Scientific history, although comparatively youthful, has many instances in which the world has waited for decades for information that might have changed history were it known. A classic example is the discoveries of the Austrian monk, Gregor Mendel, whose genetic findings, published in Brünn in 1865, were only realized when rediscovered by students at the end of the century.

This is part of the picture and the basis upon which *Biological Abstracts* has taken the initiative in the establishment of its world-wide system of cooperation among biologists. Through the contributions of students in nearly every nation on earth *Biological Abstracts* has become one of the largest cooperative enterprises ever instituted by a scientific group.

The Abstracting Mechanism Today. *Biological Abstracts* today is housed on the University of Pennsylvania campus where it was located at its inception. However, the organization has created such widespread interest amongst educational institutions that it has received invitations to establish its activities at Yale, Princeton, and other universities.

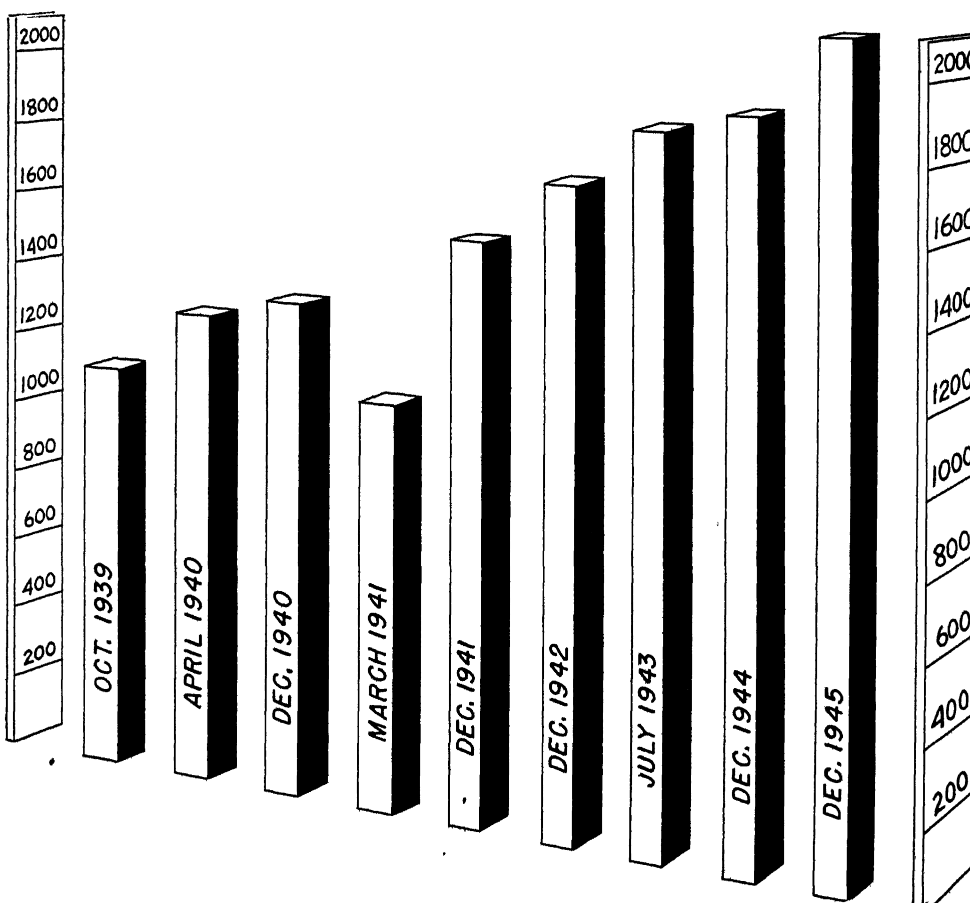
The staff of 19 salaried employees, under the direction of Dr. John E. Flynn, receive, translate, index, edit, and make ready for publication abstracts from 2,113 journals (as of December 1945), prepared by over 3,000 volunteer abstractors in America, Europe, and in every Asiatic area supporting research activities. Today that is nearly every political division on the face of the earth, and the number of sources is growing daily. The policy of *Biological Abstracts* has been, insofar as possible, to have the literature of every part of the world abstracted by workers in the country of origin. Although surrounded by combatant nations, Swedish, Swiss, Portuguese, and Turkish biologists, and those of the Latin-American nations were active throughout the recent war, and today in increasing numbers scientists from the occupied areas and those of the British Empire cooperating in this work have been able to get back to their labors of peacetime. This brings an expectancy of at least four years of accumulated research knowledge in the nearly 3,500 periodicals abroad which have not been available during that time. However, because of monetary, labor, and material shortages in many of the countries involved in the war their stock of publications will be too small to meet the demands of their fellow scientists elsewhere. Unless some form of reprint-

ing is attempted, Dr. Flynn has announced, many American and foreign libraries will be incomplete; therefore, the necessity of abstracting this material is greater than ever before. Truly an enormous task faces this abstracting organization today if this biological knowledge is to survive.

An attempt is being made to obtain authors' abstracts from as many journals as possible. At the end of 1944 about 250 such publications were being abstracted in this manner. The abstracts in each field of endeavor, however, go through the hands of the section editors, of which there are 157 covering all fields involved, before their final processing by the central office staff.

Index entries, as has been the policy of the organization, are written by students conversant with the individual field of study being indexed. About 20 to 25 persons are employed in this work and are selected from faculty and research groups. This means that a parasitologist is responsible for the parasitological studies, a forester for the ones on forestry, a geneticist for the articles on genetics, and so on.

A better conception of what this labor means might be had from the 1945 activities of the central office alone. It



NUMBER OF JOURNALS ABSTRACTED BY *BIOLOGICAL ABSTRACTS*, 1939–1945
EMPORARY DECREASE IN 1941 OCCURRED PRIMARILY BECAUSE OF UNAVAILABILITY OF EUROPEAN JOURNALS. NEW LATIN-AMERICAN PUBLICATIONS ACCOUNT PARTLY FOR INCREASING COVERAGE SINCE 1941.

received and edited 24,221 abstracts—and this in a war year; sent 1,431 messages to collaborating scientists; invited 1,529 other workers to cooperate in the work; to work out assignments, 1,010 messages were written; 427 new journal assignments were made; 193 journals were requested from various sources, and 95 additional journals were received. This was the work necessary in addition to the formation of the 10 yearly editions of abstracts, preparing the index volume for the year, and the additional required handling of the various separate sections—a new service instituted under Dr. Flynn's direction.

This latter service now makes available to students all the abstracts in their especial fields at a nominal cost. Before this was accomplished many scholars and smaller institutions could not afford the yearly edition and were thus prevented from taking advantage of this keen research tool. An important achievement of 1945 was the establishment of a new section, "Abstracts of Human Biology." Already widespread interest and support of the new venture has made the financial success of this section highly probable.

Future Aspects of Abstracting. A man of vision as well as one of action, Dr. Flynn, if asked what his future plans were, might simplify his answer to: "Today we are covering 50 percent of the research journals and sources in the world. That half includes, however, 90 percent of the outstanding and important sources. I want to see that 50 percent become 100 percent."

That answer speaks for itself. Any editor or director would want to extend the coverage of his publication. But further investigations exposed even more of Dr. Flynn's dreams of the future. To him as well as to most scientific students war is a disaster necessitated only by man's ignorance and greed. The war, however, has opened new channels for *Biological Abstracts*, Dr. Flynn said.

Enormous fields in visual education, in public health, in the biological aspects of war material, and in the newly developed physical and chemical aspects of biology now make imperative a broader and more inclusive coverage by *Biological Abstracts.*

In this he referred to the recent Army and Navy quartermaster studies of "tropicalization," which include and utilize biological knowledge. The experiences of both the Army and Navy ordnance departments in related studies he also included.

"The useful field of biological science has grown tremendously with the war years."

Medical biology, long so well known by the investigators of the tropics, now has assumed larger proportions in the northern countries and will demand more and more space in the research literature of tomorrow. This is another field that will lay still further burdens upon the abstracting services.

But Dr. Flynn and his associates are not worried about the word "burden." It does not have the accustomed connotation to them. It only adds up to the term "better coverage," the 100 percent mark at which they are aiming.

To prove this, another innovation came to the pages of *Biological Abstracts* during 1944. This was the abstracting of biological films. Today that service is limited to three fields: microbiology, immunology, and public health. The results have already brought requests for a broader coverage. Dr. Flynn now plans to extend the service, "when possible, to all biological films, of which there must be thousands available in the universities, colleges, research institutions, industries, and government agencies." This would also include, if possible, Army and Navy training films touching upon biology.

But his plans do not stop there.

"How about the availability of the material already available?" he was asked.

Dr. Flynn adds to this apparent confusion of words by saying, "It must be more available."

But this is what he meant:

Through the use of facilities now made possible through developments in the physical sciences—photocopying, electromagnetic recording, offset photolithography, and others—the dream of 100 per cent coverage can come true. It *can,* but will it? The answer depends upon the kind and amount of support *Biological Abstracts* receives.

Through modern methods the entire 19 volumes of *Biological Abstracts* printed over the past 20 years could be published in handbook size and distributed to all research students in the world for a very nominal sum. This would make this invaluable research tool available even to the beginner in science—the junior and senior students of the colleges and universities. This will become increasingly imperative because, for the first time in the history of the world, Dr. Flynn says, the furtherance of science is conceded to be an issue of national concern.

The publication of the report of the Bush Committee *Science, the Endless Frontier* and the introduction into Congress of legislation providing for a National Research Foundation are some of the events which have brought the new status of science into the nation's consciousness. It is recognized that science must advance at an ever-accelerating pace. The nation's welfare requires this.

At the same time, the adequacy of all the existing agencies that have to do with the prosecution of science is being seriously questioned. The new mood of the nation is one that inquires, Will the agencies that have been developed in the past prove adequate for the future? Can science, in its maturity, be adequately served by those agencies that were built up in the years of its infancy and early growth?

. . . While we may look with some satisfaction on what has been accomplished by *Biological Abstracts,* it is, after all, but a beginning. The world of scholarship is demanding that its service agencies, in the postwar era, shall more than keep pace with the development of science. Expansion toward absolute completeness in the coverage of the literature, and greater promptness, and greater efficiency in use will be demanded. Fortunately, *Biological Abstracts* is well equipped by experience to satisfy these demands. It does, however, present us with an opportunity and a challenge greater than this organization has so far faced.

Thus concluded the director and editor of science's greatest service to the biological sciences.

THE NATURAL HISTORY OF YELLOW FEVER IN COLOMBIA

By MARSTON BATES

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THIS article is written to illustrate a thesis: that in many situations the terms "epidemiology," "ecology," and "natural history" are equivalent, and that substitution of the terms may result in a gain in understanding. The term "epidemiology" got its start quite naturally from the study of epidemics, but the concept has gradually broadened from its origin in epidemic statistics to cover the general study of the distribution of disease—of the mechanisms of maintenance and dispersal of the causative pathogens. In this sense the etymology of the word has become a handicap—the inclusion of the *demos* (people) seems to require the fabrication of parallel concepts of "epizoology" and "epiphytology" when the host of the pathogen is an animal or plant. This sets man off from the rest of nature in a compartment that may have religious value but that otherwise seems meaningless, and the student must jump between the sciences of epidemiology and epizoology, depending on which host his pathogen happens to select next. It would seem more logical to ignore the howls of the classicists and write about the epidemiology of distemper in dogs. A few daring souls have taken this step, and I was cheered the other day to find a reference to the "epidemiology of soil-borne disease in crop plants."

Epidemiology in this broad sense could almost be defined as the "ecology of pathogenic organisms," and both ecologists and epidemiologists are becoming increasingly aware of the similarity of their points of view. The maintenance and dispersal of pathogenic organisms involves factors of environment and of population dynamics that are clearly also the raw material of ecological investigation.

The outstanding English ecologist Elton pointed out many years ago that ecology is little more than a new term for the very old subject of natural history. The modern development of ecology merely reflects the fact that our knowledge of the physiology and classification of organisms only recently reached the stage where the collection of field observations, largely abandoned during the latter part of the nineteenth century, again acquired significance. But the term "ecology" often seems to imply purely the field study of the environmental relations of organisms; and the corresponding laboratory analysis of animal behavior and of the effect of environmental factors on organisms is very generally classified under the separate heading of "physiology." Studies in both the laboratory and the field are surely necessary for an understanding of the interrelations of organisms and environments, and it seems to me that this broad point of view, which reflects in a way the unspecialized attitude of the early biologists, is appropriately covered by the term "natural history."

If we make our substitution of terms—from epidemiology to ecology to natural history—we come out with an expression, "the natural history of disease," which necessarily implies a broad point of view. It could be taken to involve an interest in the pathogen itself, in the host relations of the pathogen (which result in the disease), in the environmen-

tal relations of the host which often so strikingly affect the pathogen and the course of the disease: in short, an interest in the interplay of factors involving pathogen, host, and external environment. The importance of this point of view is particularly clear in diseases involving vector relations or an alternation of hosts; and the point of view becomes a necessity when the disease is set in the tropical forest. All of us working on yellow fever have become naturalists of a sort, willy-nilly, from sheer force of circumstances. But the point of view might be equally valuable, though less obviously so, in a study of measles.

Not many years ago we thought we knew all of the essential facts about yellow fever. It was a purely human disease transmitted by a domestic mosquito (*Aedes aegypti*) and maintained by large concentrations of human populations in environments favorable to the development of the mosquito (tropical cities), occasionally spreading as a fearful epidemic to peripheral environments (northern cities). There was much evidence indicating an African origin of the disease—the vector mosquito, in particular, was apparently an African insect introduced into America with the slave trade or traffic from the Mediterranean. The urban aspect of yellow fever was most pronounced in the New World, and everything seemed to indicate that a sufficiently energetic and well-planned campaign of mosquito control in the major cities of tropical America, which appeared to be the centers of dispersal, would eliminate the disease from this hemisphere. The Rockefeller Foundation embarked on an ambitious project of study and control with this objective clearly in mind.

One could probably draw a moral of some kind from the history of this Foundation project. It ended by demonstrating that the original objective—the elimination of yellow fever from America—was impossible; after twenty years of continuous study by groups of investigators in Africa, Brazil, and Colombia, the clear concept of yellow fever epidemiology that prevailed in 1925 has become as extinct as the dodo. Any statement of yellow fever epidemiology made today is an ungainly construction, tacked together with words like "probably," "possibly," and "very likely." Yet, by a process that could hardly have been foreseen in 1925, yellow fever has been reduced to one of the most completely preventable of human diseases. The Foundation project is probably one of the most successful of large-scale, organized attacks on a medical problem—though the success was not according to plan. It might be called an accident, since the actual shift in virus pathogenicity that resulted in the vaccine strain (17D) seems to have been a random occurrence not repeatable at will—but the accident would not have occurred without the plan.

The story of yellow fever vaccine is irrelevant to our present thesis, though its development is closely interwoven with the change in our concept of virus epidemiology. The great step in taming yellow fever was of course made by Reed, Carroll, Agramonte, and Lazear in 1900 with their justly famous experiments demonstrating transmission by *Aedes aegypti*. Further work was almost impossible because of the lack of a suitable laboratory animal, and a search for such an animal was the first item on the Foundation research program. The discovery in 1927 by Stokes, Bauer, and Hudson of the susceptibility of the Indian rhesus monkey to the pathogen of the disease was perhaps the next great advance. It resulted almost immediately in many basic discoveries: the clear demonstration by Sawyer and his co-workers that the causative pathogen was a virus; the discovery by Max Theiler (at that time working outside of the Foundation

group) of the susceptibility of the white mouse, which at once became an invaluable tool; the demonstration by N. C. Davis and others of the susceptibility in varying degrees of many South American monkeys, and of the fact that many mosquitoes besides *Aedes aegypti* could transmit the disease under laboratory conditions. The demonstration by Theiler of the modification of the virus by brain passage in white mice at once gave impetus to attempts to develop a strain nonpathogenic for man that could be used as a vaccine; the successful conclusion of this study was announced by Theiler and Hugh Smith in 1937.

It is difficult for those of us who started working with yellow fever after the development of the vaccine to realize the hazards that were faced in those earlier studies. A very high proportion of the investigators contracted the disease, despite the most elaborate precautions, and several died. The immunization of laboratory personnel by the simultaneous inoculation of "fixed" mouse virus and immune serum was started in 1931 by Sawyer, Kitchen, and Lloyd, and in 1936 the much simpler vaccination with the nonpathogenic 17D strain was introduced. Since 1931 there has been no case of laboratory infection, although the number of people working with the virus has increased tremendously. The virus is handled with the nonchalance that would characterize studies of *Bacillus coli*. It is dangerously safe since one must be constantly alert not to allow the development of careless habits that might be carried over into work with some other pathogen not so thoroughly tamed.

Epidemiological studies were also being carried out through all of this period concurrently with the laboratory work, and these were greatly facilitated by two new tools. First, the discovery of the susceptibility of the white mouse made available a cheap and easily handled animal for neutralization, or protection, tests—for surveys of immunity in human or other populations. Postinfection immunity to yellow fever is lifelong in man, and the presence of such immunity can be determined by a simple test involving the inoculation of a mixture of the human serum and virus in mice. By means of such "protection test" surveys, the distribution of immunity to yellow fever—which means the distribution of individuals who have at some time been infected—can be determined; an idea of the intensity of regional infection can be obtained from the proportion of immunes; and an indication of the time when yellow fever was last present in an area can be obtained from the minimum ages of individuals showing immunity. If children show immunity, the disease has clearly been present in the population in recent years.

The second new tool of the epidemiologist is called the "viscerotomy service." It was long ago discovered that the human liver shows a characteristic pathology in fatal cases of yellow fever; since isolated cases of such a disease may be difficult to diagnose, pathological examination of post-mortem tissues may become an important factor in deciding the nature of a particular infection. Workers in Brazil developed a simple instrument, which they called a "viscerotome," for rapidly removing a small piece of liver tissue from a cadaver without undue mutilation—an instrument that could be handled by persons with no medical training. By establishing a network of posts through Brazil so that liver tissue could be obtained from large numbers of persons dying of acute febrile illness, a method was at hand for checking on the incidence of deaths from yellow fever even in areas where no medical service was available.

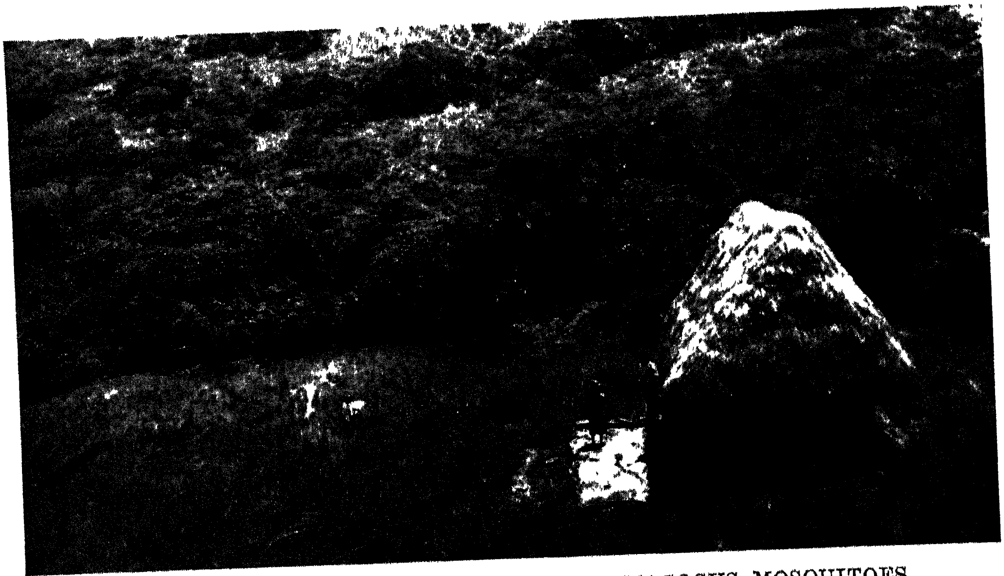
Immunity surveys and pathological examination of the material submitted

by the viscerotomy posts revealed that yellow fever was much more widespread in Brazil than had previously been supposed. At about the same time that this discovery was made, urban epidemics occurred in certain parts of Brazil and Colombia under conditions where the source of the virus could not be determined—unless it had come from sparsely inhabited forested areas, which was in conflict with what was known about the epidemiology of the disease. It was also discovered about this time that yellow fever was present, and had been present for many years, in certain parts of Colombia where the known vector mosquito *Aedes aegypti* did not occur. All these things together led to the development of the concept of "jungle yellow fever"—of yellow fever continuously present in the forest, occasionally and fortuitously infecting man, and occasionally reaching towns and cities where it could be picked up by *Aedes aegypti* and converted into the classical urban disease. Studies of the possible mechanisms of maintenance and dispersal of this forest yellow fever were started in Brazil and Colombia in 1934; and in 1938 a well-equipped virus laboratory was installed at Villavicencio in eastern Colombia for the express purpose of studying the epidemiological aspects of this disease.

The presence of yellow fever in the Villavicencio region first came to medical attention in 1934, but there is every reason to suppose that it had long been present in the area, undiagnosed. Careful studies over the next three years revealed many clinical cases of yellow fever, always in persons with some history of contact with the forest: usually woodcutters or farmers clearing land, occasionally people with more casual contact with the forest such as a child who had carried lunch to a father at work. There was no hint of man-to-man transmission by domestic mosquitoes, and in fact *Aedes aegypti* was found to be completely absent from the region Townspeople who stayed out of the woods were apparently perfectly safe. A similar situation was found in other parts of Colombia, notably in the region of Muzo where the emerald mines are located. Villavicencio was selected as the site of the laboratory largely because an automobile road was completed across the Andes in 1937, making the town relatively accessible.

The first two years of the life of the Villavicencio laboratory must have been very discouraging, because not a single proven case of yellow fever turned up in the region. Cases had been found every year previously and have been found every year since except for the year 1945. For the absence of the disease during 1945 we believe we have an explanation: the severest dry season of which we have a record resulted in the complete disappearance of vector mosquitoes from our study areas, and we think the virus may have died out and that it will take time for it to filter back from the regions of more constant rainfall to the south of us. Something of the sort may have happened in the dry season of 1937–38, but comparisons are difficult because a standardized system of weather and mosquito records had not yet been installed. The investigators at Villavicencio during that period put their time to very good use, however, in making laboratory studies of the susceptibility of animals of all sorts—mosquitoes, ticks, reptiles, birds, mammals—and in perfecting techniques of study. When the first human cases were discovered in 1940, they were thus ready to take maximum advantage of the occurrence.

The law requires that a representative of the laboratory must sign the death certificate before any corpse can be buried in Villavicencio. If the case history shows an acute febrile illness with



THE COLOMBIAN FOREST—HOME OF HAEMAGOGUS MOSQUITOES

A WOMAN WHO LIVED IN THIS HUT DIED OF YELLOW FEVER; SHE WAS ACCUSTOMED TO WASH CLOTHES IN A STREAM AT THE MARGIN OF THE FOREST WHERE HAEMAGOGUS MOSQUITOES WERE ABUNDANT. THE COUNTRY PEOPLE OF EASTERN COLOMBIA GENERALLY LIVE THUS, IN CONTACT WITH THE FOREST.

onset of symptoms less than ten days before death, a liver specimen is taken by means of the viscerotome for pathological study. In this way quite a few otherwise unrecognized cases of yellow fever have been discovered. The local physicians are also very cooperative and call attention to any case that might be yellow fever. When such a case is seen, if the patient's blood smear is negative for malaria, blood serum is inoculated into mice to attempt isolation of yellow fever virus. Yellow fever is a disease of country people, and these people do not come into town for medical assistance unless they are very sick indeed; if the infection is yellow fever, "black vomit" (from stomach hemorrhage) has usually set in, and there is little doubt about the diagnosis. And the prognosis, as the medicos would say, is very unfavorable.

The method, when there was strong reason to suspect a case of yellow fever, was to question the man or his family as to his movements during the week previous to the onset of symptoms. Almost always the individual had been working in some specific patch of forest during this time, either clearing land or lumbering. Sometimes this patch of forest was a day or more away from the laboratory on horseback; in a few instances, it was within half an hour or so of the laboratory and easily reached by car. In either case, an intensive study was made of that particular patch of forest in an effort to localize the source of the virus. A camp was established when the forest was not within easy reach of the laboratory, and all of the apparatus necessary for a field study of virus was carried in: cages of white mice and monkeys, sterilizing equipment, and glassware, as well as the normal supplies necessary for any isolated encampment. This work was largely carried out by Dr. John Bugher and Dr. Jorge Boshell-Manrique, both equally at home in the forest or in the laboratory and both of whom had the "natural-history" point of view as defined at the beginning of this article.

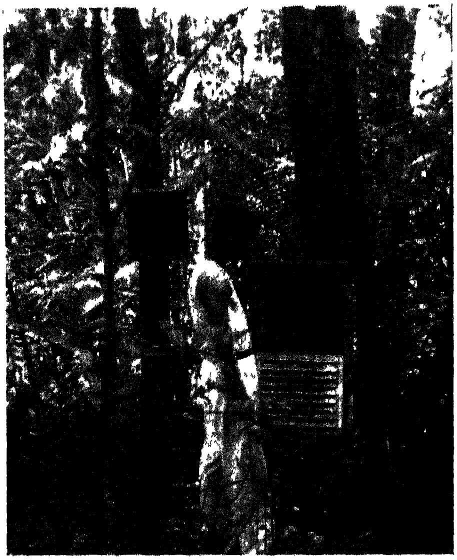
The results that had been accumulat-

ing both in Brazil and Colombia indicated that the mechanism of yellow fever maintenance in the forest was probably a mammal-mosquito cycle, and efforts in these field studies were largely concentrated on attempts to isolate virus from mosquitoes and to determine the extent of immunity (indicating previous infection) among mammals. One particular mosquito, a bright metallic blue species called *Haemagogus capricornii*, was early suspect both in Brazil and Colombia. Many attempts were made to transmit virus with this mosquito in the laboratory, but with little success The mosquitoes were very difficult to keep alive under laboratory conditions, and even when they could be kept alive for what seemed an adequate period, transmission did not occur or was irregular. Yet the mosquito was always turning up where there was sylvatic yellow fever, and in 1938 workers in Brazil recovered virus from wild caught specimens of this species.

Dr. Boshell made a basic discovery about this mosquito very early in these field investigations. He had gone into patches of forest where men who had been felling trees had contracted yellow fever and yet he had found very few mosquitoes. The men claimed that they had been pestered with clouds of mosquitoes while working, and one day he accompanied such a group and found that this was true: mosquitoes would be scarce in the undisturbed forest, but as soon as one started to fell trees, they appeared in great numbers—mostly haemagogus. They were activated by disturbing the forest. For a while he tried deliberately felling trees to get mosquitoes for virus studies; then he started wondering where the mosquitoes were before the trees were felled. I do not know where or exactly when he first climbed a tree to look for haemagogus, but it was not long before he had his answer: the mosquitoes were normally in the forest canopy and came down to bite in large numbers only when the forest was disturbed. By climbing into the canopy they could always be found.

From that time on, haemagogus could be collected in large numbers in these areas where yellow fever was contracted. Many thousands were inoculated into mice and monkeys, and during a year of work virus was recovered from such mosquitoes on thirteen occasions. The prime requisite for a study of the epidemiology of yellow fever became agility at climbing trees, and it was increasingly clear that the habitat of the disease was the forest canopy. We now understood why yellow fever in eastern Colombia could be characterized as "an occupational disease of woodcutters."

At this point yellow fever again became a laboratory problem: there was ample evidence from field studies that the haemagogus mosquito was the main vector of yellow fever in the area, yet attempts to obtain transmission under controlled laboratory conditions continued to give negative or anomalous results. Haldane has remarked somewhere that biological research consists of "asking nature simple questions one at a time." The work had reached the point where we could frame our questions in fairly simple terms and take them up one by one. First, there was the question of how to keep haemagogus alive in the laboratory long enough to carry out adequate transmission experiments. We worked on this off and on for two years, with a notable lack of success. Our experiments are perhaps worth mentioning as a fine example of human failure to add up an obvious two and two. We were making rather detailed ecological studies of haemagogus behavior in the forest, and for this purpose we built ladders and platforms in trees, making observations on the vertical gradients in temperature, humidity, and light and collecting statistics on the



THE FOREST FLOOR
RECORDS ARE MADE HERE OF ENVIRONMENTAL CONDITIONS IN THE FLOOR ZONE OF A STUDY AREA NEAR THE LABORATORY AT VILLAVICENCIO.

occurrence of haemagogus with relation to these gradients. We had thermographs at different levels and in general learned a deal about the physical environment of the forest. We of course studied conditions at ground level as well as in the canopy; and for those first two years we continued to think of this ground level environment as the total forest environment and to try to reproduce ground level conditions for maintaining our mosquitoes in the laboratory. We knew haemagogus avoided the ground level in dense forest but we failed completely to make the obvious deduction from the field to the laboratory, even though these studies were being carried out by the same people at the same time.

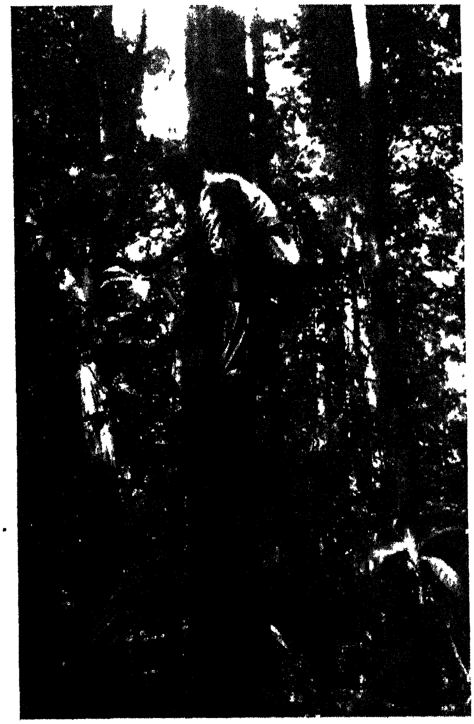
One trouble was that our methods were conditioned by previous work on anopheline mosquitoes. Anophelines fly at night and generally seek some cool, dark resting place in the day: in the laboratory they should be kept in a cool and moist environment for maximum longevity. The ideal place to keep anophelines is in a cellar. We dug a cellar, fixed it up with time switches for controlling light cycles, and achieved a splendid reproduction of conditions prevailing at ground level in the forest. Anophelines were perfectly happy in this cellar, but haemagogus died off within four or five days.

We were at the same time trying to find some way of getting large numbers of eggs from haemagogus. We again tried an anopheline technique—putting individual mosquitoes in small shell vials with a moist filter paper pad in the bottom. Haemagogus responded well to this treatment, laying good numbers of eggs. I think again it was Dr. Boshell

ABOVE THE FOREST FLOOR
THIS PLATFORM IS FOURTEEN METERS ABOVE GROUND LEVEL, OVER THE THERMOGRAPH STATION OF THE PRECEDING PHOTOGRAPH. HAEMAGOGUS MOSQUITOES ARE ABOUT FIVE TIMES MORE ABUNDANT HERE THAN AT THE GROUND.

who first noticed that mortality was surprisingly low in these vials and who first thought of trying to use the vials for maintaining haemagogus. To get eggs rapidly, we kept the haemagogus in an incubator which had an electric fan built in to avoid air stratification. The haemagogus lived beautifully in this incubator, so it seemed that the proper technique with haemagogus was to keep them warm and dry; in other words, to reproduce the physical conditions found at midday in the forest canopy, not those found at ground level.

We continued trying to make laboratory transmission experiments at the same time that we were learning how to keep the mosquitoes alive for longer periods. There were many other difficulties, and one of our biggest needs was large numbers of some suitable experimental mammal from the local fauna. The rhesus monkey remained the standard animal for yellow fever experiments after the discovery of its susceptiblity by Stokes, Bauer, and Hudson; but rhesus were difficult to get in wartime, very expensive at any time, and experiments with an exotic mammal could not be interpreted in terms of local epidemiology. The immunity surveys of local mammals had shown positive results among many different species, more especially species of marsupials and primates. We spent a year working on the marsupials, trying to use them as source animals for mosquito infections, before giving up and starting on the local monkeys. One of these monkeys, the saimiri, had been found to be very susceptible many years before by N. C. Davis, working in Brazil, so this species was tried first. We found that it circulated large amounts of virus regularly, often showed clinical symptoms of illness, and frequently died in the course of infection. It seemed to be an excellent laboratory animal. It took a year of propaganda to get the local people to catch them in quantities, and they got in the habit of selling us monkeys just about the time we were really ready to make use of them.



TREE CLIMBING
THE LABORATORY STAFF HAVE BECOME EXPERT AT BUILDING LADDERS IN TREES; THE LADDERS ARE MADE IN FOUR-METER SECTIONS AND ARE THEN NAILED TO THE TRUNK. THIS PARTICULAR TREE IS USED FOR THE STUDY OF MOSQUITOES BREEDING IN A SERIES OF CAVITIES IN THE TRUNK.

Even with these monkeys, haemagogus did not transmit virus regularly. We thought there might be something wrong with our virus strains, which had been subject to a lot of unnatural laboratory manipulation in the course of the exploratory experiments. Sporadic cases of yellow fever were continuing in the area, and it was fortunately possible to obtain two new strains. We obtained one of these strains very conveniently right in the laboratory. A man came in one day with a note for Dr. Roca from one of the town physicians, who

A SUSCEPTIBLE MONKEY

THE SAIMIRI MONKEY (*Saimiri sciureus caquetensis*) IS THE MOST ABUNDANT PRIMATE IN THE VICINITY OF VILLAVICENCIO AND IT IS VERY SUSCEPTIBLE TO THE VIRUS OF YELLOW FEVER.

was puzzled as to the nature of a skin rash and wanted Roca's opinion. Roca questioned the man and learned that he had come to town because his brother, with whom he had been working in the forest, had died a few days before with "black vomit," scaring him sufficiently to make him think of making the long trip for vaccination. He had a slight fever and headache, a slow pulse, and yellow eyeballs. Roca, in the course of his years of study of yellow fever in the region of the emerald mines, had seen an immense number of cases of all grades of severity, and he suspected that the man might be infected. He took a blood specimen, which was inoculated directly into a saimiri monkey, and recommended to the man that he go back home to bed. The monkey died nine days later and served as the source animal for a strain of virus that was kept constantly going in the laboratory by haemagogus transmissions from monkey to monkey for a year. The man, we learned later, did not follow Roca's advice about going to bed; his headache got better in a day or two, and he went back to work. Roca got hold of him again a month later to make a blood test for yellow fever immunity (he had not been vaccinated after all), and this later sample showed clear protection for yellow fever, in contrast with serum saved from the sample taken at the time he appeared in the laboratory.

With these new virus strains and with the new handling of haemagogus, there was no trouble at all in maintaining transmissions in the laboratory. We were able to study the effect of various factors on virus development in the mosquitoes, and one of the most important and most interesting of these factors

A SUSCEPTIBLE MARMOSET

THIS MARMOSET (*Oedipomidas oedipus*) REPLACES THE SAIMIRI MONKEY IN SOME PARTS OF COLOMBIA WHERE YELLOW FEVER IS ENDEMIC; ALL THE MARMOSETS SEEM TO BE VERY SUSCEPTIBLE TO THE DISEASE, AND STUDIES IN BRAZIL INDICATE THEY ARE IMPORTANT HOSTS OF THE VIRUS OF SYLVATIC YELLOW FEVER.

proved to be environmental temperature If the mosquitoes were kept at a constant temperature of 25° C., few became infected, and the incubation period of those few was greatly prolonged. If the mosquitoes were kept at a constant temperature of 30° C., a very high proportion (usually all) became infected, and the incubation period might be as short as ten days. Constant temperatures of 30° C. are unknown in our forests, so we started testing alternating temperatures. We found that twenty hours a day at 25° and four hours at 35° gave almost as good results as the constant temperature of 30°, as far as virus development was concerned, and that the mosquitoes subject to such alternating temperatures survived for very long periods—forty or fifty days quite commonly. If kept at a constant temperature of 35° C., they lived for only a very few days and they must have been subject to serious physiological disturbance since they laid no eggs and were induced to feed again only with difficulty. To study the effect of temperature, a group of mosquitoes that had fed on a given infected monkey would be divided at random into several lots, which were kept under the conditions to be tested; we were thus sure that the condition of infection of the mosquitoes was uniform. One such group that was divided into five lots maintained at different temperatures and tested for transmission every day gave the following results:

Temperature Condition		First Transmission
Constant	35°	No transmissions
Constant	30°	10 days
20 hrs.	25°, 4 hrs. 35°	12 days
20 hrs.	25°, 4 hrs. 30°	23 days
Constant	25°	28 days

In other words, four hours' daily exposure to the (for a mosquito) very high temperature of 35° brought the virus incubation period down to a reasonable length of time. We have never found a shade temperature of 35° in our forests, but the bright blue haemagogus are often found in the sunlight. Various investigators have found that insect body temperatures in the sun rise quickly to temperatures in the neighborhood of 40° C., so haemagogus flying in the sunny areas of the forest canopy may well be daily exposed to fairly high temperatures. It is difficult not to believe that their metallic coloration is an adaptation to life in an environment of relatively low humidity and high temperature. The brown-and-grey nocturnal mosquitoes and the dull-colored mosquitoes of the ground level zone of the forest survive for only a few days under the laboratory conditions that we use for maintaining haemagogus; yet these dull grey-and-brown mosquitoes will live for weeks in our cellar where haemagogus die in four or five days.

We have thus come to form a picture

MAINTAINING HAEMAGOGUS

HAEMOGOGUS MOSQUITOES ARE BEST MAINTAINED IN THE LABORATORY IN INDIVIDUAL SHELL VIALS WITH DISCS OF MOIST COTTON IN THE BOTTOM, PLUGGED WITH WIRE GAUZE; THESE TUBES ARE MAINTAINED IN A RELATIVELY WARM AND DRY ENVIRONMENT, LIKE THAT ATOP THE FOREST.

of yellow fever as a disease of the forest canopy, carried on by continuous cycles among the arboreal monkeys and the canopy mosquitoes. Many local mammals can be infected with yellow fever, in the sense that some virus can be recovered in circulation after laboratory inoculation, but as far as we know only the common monkeys circulate enough virus regularly to infect these haemagogus mosquitoes. Around Villavicencio saimiri is our commonest monkey; in many parts of Brazil marmosets are the abundant monkey, and they show the same infection behavior as saimiri; in some parts of Colombia where yellow fever occurs, the douroucouli seems to be the only monkey present, but it proved to be the most susceptible of all in laboratory experiments with haemagogus. These monkeys and mosquitoes show the same ecological distribution, and the physical environment of their habitat, the forest canopy, must be reproduced if the mosquitoes are to be kept alive in the laboratory; and these same physical factors seem to be a prerequisite for virus transmission by these mosquitoes.

It is, of course, impossible to be sure that we have all of the basic facts involved in the maintenance and dispersal of yellow fever virus in the South American forest. It would not greatly surprise any of us, for instance, if someone should prove tomorrow that the virus can be maintained through transmission by some species of tick among common opossums. All the experimental work with such mechanisms has given negative results, but negative results are notoriously difficult to evaluate. We do have a working hypothesis which at the moment gives us a certain amount of intellectual satisfaction and which seems to fit the known facts—around Villavicencio at least. And this hypothesis of maintenance by haemagogus transmission among arboreal monkeys seems a particularly nice illustration of the value of the "natural-history point of view" in studies of disease: of the value of the combination and alternation of field and laboratory studies, of separate yet integrated work on the biology of the pathogen, the vector, and the host. The neatness with which the data obtained by ecological studies of the environment of the forest canopy serve to interpret the data obtained in laboratory studies of mosquito infection is especially striking; in fact, it seems too neat and simple to be true. We are sure, however, that "epidemiology" in the strict sense of the word is a meaningless term as applied to sylvatic yellow fever since the basic spread of the virus is certainly epizootic. Even a study of the "ecology" of yellow fever would have little meaning without the laboratory work on virus behavior.

It is interesting that the various scientists involved in these studies of sylvatic yellow fever started out as members of fixed professional categories, as pathologists, entomologists, or physicians. The men who made the greatest contributions, however, soon were working well outside the field of their professional classification: pathologists classifying mosquitoes, physicians trapping mammals, entomologists making studies of virus circulation in monkeys. I think no one consciously intended to study the "natural history of yellow fever"; the point of view grew out of the necessities of the subject. But in surveying the studies that have been made, the value of this point of view seems obvious, and it seems very possible that the deliberate cultivation of such a point of view in other, less obvious, situations might be productive of very worth-while results.

THE PLACE OF FEAR IN THE SCHEME OF THINGS

By A. G. KELLER
YALE UNIVERSITY

FEAR is not a pretty thing. Nor is regret. Paradise contained neither one. Neither figures in any blueprint of a New Jerusalem. A rarity is the statesman in office who dares to forecast the genuinely fearsome; it is left to the opposition to "view with alarm." What men want is to eat, drink, and be merry. In dire peril, too imminent to be ignored, they have risen to the lift of a great Leader; but as soon as they cease to fear, they are ready to slump back into the comfort of "normalcy," relaxation, forgetfulness of experience, credulity ready to be played upon by any plausibly dressed-up Santa Claus.

The tendency of the People is to lie back after effort into an *otium,* not *cum,* but *sine, dignitate.* The higher tension of fear is too strenuous to be borne very long; and a welcome torpidity ensues upon its relaxation. The *esprit de corps* ravels out. The People repudiate their saviors when the anxiety that forces the facing of peril has been removed under heroic leadership. Let the names of Clemenceau and Churchill stand for this return to otiose "normalcy," with nothing to fear but fear.

Fear is one of those sour-faced inevitables that stir men out of their otiosity into spurts of desperate joint action. It is the prime awakener that can bring them to their senses, that can tap whatever residual common sense they possess. "Ties of common funk" have held men together in effective association, at least during a crisis-time. They may be the only effective ties, in view of the newest instrument of destruction, to bind the nations into an inclusive peace-group. The pressure of danger from without has secured an inner cohesion, as in time of war. That such unity often promptly dissolves with the removal of the fear-pressure emphasizes the truth in the case.

In general, a life without fear would resemble a railroad that has scrapped its red signals in favor of a policy of sheer recklessness. The recognition of peril causes men to try to do something about it. What they have done has generally been more miss than hit, for they have had available for long ages only the trial-and-error method. But even their random dashes up one blind alley after another, with ensuing emergence in sorry plight, have taught them one great truth: that you have first to learn where it isn't before you find out where it is.

Men learned (as they slowly and painfully explored the blind alleys and ruefully nailed up signboards labeled "No Thoroughfare") not *not-to-fear,* but *what-to-fear.* Here was a kind of breakdown of an all-pervasive general fear into its specific parts, some of which men could then learn to forecast, dodge, or even handle. Thus arrived discrimination.

To banish all fear by some formula of exorcism, or to adjure mankind to shut their eyes to it, is to challenge the historic process by which the race has been taught, by experience, *what-to-fear.* It is anxiety that has begotten caution, a corrected forecasting, the demand for a regularity that could be counted on. It has driven men to work, to save, and to safeguard by law the results of labor and thrift. Above all, it has caused them to take heed of experi-

ence, to remember and record its teachings. Fear is neither all bad nor all good; it is something very strong and inevitable, like gravitation. It is not to be thwarted by some kind of liquefaction or levitation.

Discomfort arises from maladjustment. All men's institutions—the industrial organizations, property-systems, regulative (governmental) systems, religious systems, family organizations—develop as adjustments and re-adjustments, to society's life-conditions. All of them confer a degree of regularity and security in a world of ominous insecurity and well-justified fear of misfortune. All are insurance-devices, developed very gradually and unpremeditatedly against pain and loss. Insurance is effective mainly in distributing calamity so that it can be borne by the individual, who pays for it in premiums of work, of self-denial in myriad forms, of taxes and tithes—in a general and comprehensive effort to erect bulwarks against dangers always present and always to be feared by those possessed of a grain of insight. Only the fool, together with the god who is supposed to look out for him, can be nonchalant in the case.

It would be much more agreeable on earth if fear could be dissipated by a lighthearted gesture, by injunctions of trustfulness, by a wishful optimism preached by the sincerely naive or by disingenuous exhorters with axes to grind. For fear is there, and to stay, in the Scheme of Things. Something that it is well to fear is always at hand. There is nothing for men to do except to make the best of it. The way to make the best of it is to recognize it, study it, and adjust to it. By those so doing, it can even be used to minimize the ill it threatens.

That is exactly what has been done in the case of other inalterable life-conditions: men have learned *what-to-fear* and, to some degree, how to evade it: for instance, how to deal with fire or epidemics. Consider the latter for a moment. Among savages, when several unaccountable deaths have occurred, the survivors flee the region, abandoning planted crops and other valued possessions; but in time men dared to stand fast, to hang on to their property, and to lay quarantines or use prophylactics and medicines. Except for their fright, none of these developments would have occurred, any more than with animals; the afflicted would merely have died. It is irrelevant that their fears scared them up many a blind alley; it was being thrown out that taught them the signboard habit. It is true that signboards become weathered and "old," and no longer prevent zanies from dashing up the alleys, chanting: "It will not be so this time!" The pity of it is that they so often stampede credulous innocents to go along.

Freedom from fear, as a form of general felicity, is a utopian conception, inexpedient, to judge by the experience of the race, even were it realizable. "Ideologies" that strain after and promise satisfaction of yearnings, are alluring, especially if decked out with a panoply of noble sentiments. They always lean toward universals and absolutes. But universal propositions are exceedingly vulnerable, for it takes only one single exception to ruin them; and there are plenty of places along the road toward civilization where freedom from fear would have been disastrous to all that we call "progress." Faced with exceptions, the easy generalizer of universals is obliged to wriggle: "Of course, I did not mean that kind of fear"; or to galvanize the hoary "argument" about the exception proving the rule. And as for absolutes, none exist except, perhaps, absolute nonsense.

The truth is that there are fears *and* fears. Some of them can be dissolved and some not; but no one of them flees

incontinently at even the kingly word: "Avaunt!" Fears also are like wants, in that any satisfied want merely breeds more wants, just as the lopping off of one of the Lernaean Hydra's heads resulted in several sprouting, in a geometrical progression, from the stump.

The injunction to banish all fear has been known to be nothing but a device, like the shooting of the prestidigitator's pistol, to divert attention from some trick the enjoiner is about to pull off. What that kind of injunction may mean is: "Don't fear Me"; and is often accompanied by the suggestion of new fears that shall inspire uneasiness and flight when no man pursueth. If you can get several timid souls on the run, a chase is on, even out of mere curiosity, with a lot of diversion for all hands except the goats. The invention of empty fears and the starting of a hue and cry after some selected victim are stock methods of propaganda: elderly devices, but, like Helen of Troy, seductive, even in advanced years, as ever.

The promise of something for nothing, in this case a gratis emancipation from anxiety and care, has taken in many generations of mankind, despite all warnings to fear those bearing gifts. There is a substantial ransom exacted for any genuine release from fear, namely, serious, steady, protracted effort in patient toil and study—as the accredited sciences have demonstrated; and no more is to be expected than one small conquest at a time over ignorance and in the correction of error. Never one grand leap to security by way of some proclaimed New Order of the Ages. For there is no royal road to the knowledge that alone can enable mankind to discriminate between fears: those that are fictitious; those that can be nullified in whole or in part; and those actual and durable fears that must be recognized and met by such adjustments as are possible to men.

It has been contended that anything that even only apparently and equivocally banishes fear is legitimate because it promotes confidence and makes for morale. Much has been claimed for faith, however blind. Napoleon is cited for his pronouncement that morale (spirit, *esprit de corps*) is to other military assets as three to one. Fanaticism has had its acclaimed successes all through history, and to this day. As a "shot in the arm," it has incited to what looked at the time to be astonishing and even permanent results. Its administration has been at the hand of a series of prophets who have attained to dictatorships; and some of these Leaders have lasted quite a while and have even been deified after presumable death, so that the fanaticism they inspired has survived them, having freed itself from its human origin and turned into an article of belief, pure and simple—into some kind of Absolute Faith henceforth immune from all critical examination. A Doctrine has been born which comes to be viewed reverentially (note the "fear" in the etymology of "reverence"); that is to say, it has become a thing in itself that emanates fear, a reverence for what is supposed to confer security against all other fears, including that of death and damnation.

No such faith has withstood disillusionment through experience, though the most earnest and ingenious effort has been expended in explanations, alibis, interpretations, and apologetics to prove its infallibility, and so to shore up a slipping morale dependent upon it. With disillusionment have returned, in greater strength, all the uncertitudes and fears of insecurity against which faith had decreed a permanent banishment.

As a covering illustration of the handling of fear, consider the fear of war. There is nothing that men have dreaded more, or more ardently prayed against. But wars have gone on; and the burden

of proof that they can be banished by supplication has been too heavy for any faith to bear, no matter with what agility in the invention of explanations the official representatives of that faith have been able to exhibit. In the end, all these apologetics shrivel up into: "Wars recur because they recur," which has never afforded much comfort to anybody, for it offers nothing but insecurity to count on.

It ought to have become evident, by now, that the only way to try to limit war is the way taken, after sad disillusionment, in the case of disease. There was never any prospect of banishing disease by cursing it in some grand ceremony of anathema, or by taking vows never to tolerate it, or by passing resolutions, in convention assembled, against it, or by trying to ignore or banish its characteristic symptoms—to drive in an eruption so that it is out of mind because out of sight. But that is exactly the way that frightening social maladies, of which war is only one, have been traditionally handled: by any handy magical means that could be plausibly suggested to "openmindedness," that is to say, to credulity unchecked by the common sense that, in last resort, takes painful and rueful heed of the givings of experience. Plain sense had to do that from the outset in cases where the cause-effect sequence was too obvious to be missed by minds sensitized by the nearness of peril; but it was a long time before that sequence was actually sought out and studied, when "native" common sense had been refined into the "trained and organized" common sense of science.

Here is an old, old story that has been little heeded because dull to minds fed on wishfulness, and soon forgotten. The fear of the Ways of Things, which are personified as "The Lord" or "Fate," is still the beginning of wisdom; and the only sane and safe course is to go on seriously, sturdily, studiously, honestly, courageously, from that beginning.

OREGON'S WONDERLAND OF THE PAST—THE JOHN DAY

By CHESTER STOCK

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Clear comprehension of the story of the past life of the earth as revealed in any one region often depends upon a succession of favorable circumstances. While it is commonplace to say that the ravages of time leave their impress on things material, they are probably never so much in evidence as in that organic record of the past scrutinized by the student of the earth sciences. Indeed, the chance occurrence of a geologic event is often responsible for those tantalizing uncertainties in paleontology which in themselves serve as incentives to read and interpret earth history.

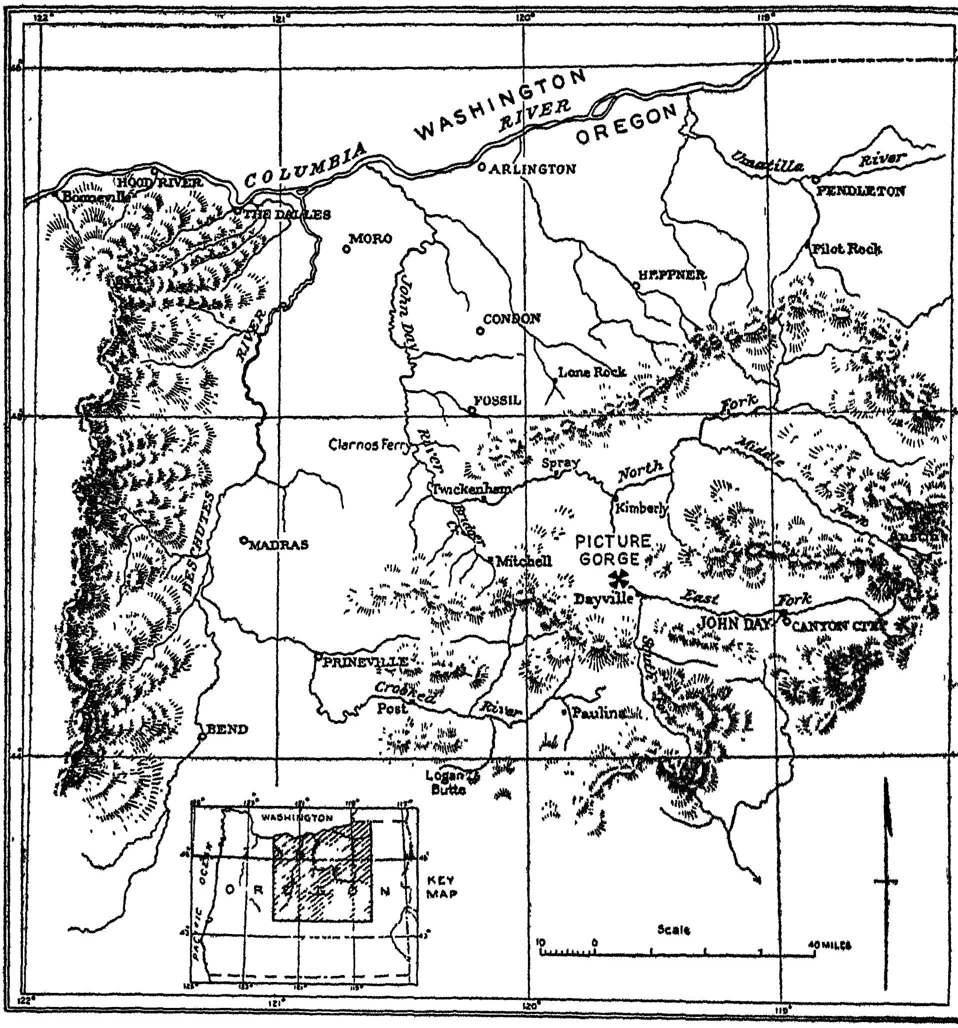
In any attempt to follow the flow of life through the geological ages on the basis of fossil remains, there must be available, first of all, an adequate amount of material, and the organic remains themselves must be sufficiently well preserved to permit a ready identification. Agencies which come into being on the death of an organism may be so destructive and may continue to act so adversely to its preservation that one never ceases to wonder at the surprisingly good quality of much of the testimony derived from the rocks.

Much less significant today than formerly is the accessibility of collecting grounds—often badlands—where this kind of fossil record is uncovered, for modern transportation and communication facilities, in our own country at least, have overcome the difficulties which most terrains offered to the pioneers and early explorers. Probably of greatest importance, however, is the requirement which certifies the position of individual stages in the historic sequence with regard to the superimposed rock formations or strata in which they occur.

Perhaps nowhere in North America are these conditions met quite so favorably, nor does a representative portion of the past history of mammalian life unfold so clearly and impressively as in the John Day region of north-central Oregon. Here, in at least five out of seven or eight readily recognizable and superimposed formations occur the skulls, teeth, jaws, or skeletal elements of extinct mammals. Complete and articulated skeletons are found much less often. But whether complete or not, these are the remains of once living creatures that date from several distinct stages in geological time.

In the millenia that have elapsed since their accumulation in the sands, gravels, muds, or ash of a former time, the sediments themselves have been compacted and hardened and more or less altered. In the course of this accumulation and alteration the organic remains have likewise undergone change. Thus the organic substances which originally made up the tissues of bone and tooth are often found to be replaced by inorganic salts like lime and silica, and this replacement has turned individual specimens more or less to stone. Petrifaction, as this mode of preservation is called, commonly characterizes the fossil mammalian material found in the John Day area and is an important factor in allowing the specimens to retain their identity through the long period of their entombment.

The strata in which this significant history of life occurs are only a part of



Modified after Chancy

THE NORTH-CENTRAL PORTION OF OREGON

SHOWING THE DRAINAGE BASIN OF THE JOHN DAY RIVER AND THE LOCATION OF OREGON'S WONDERLAND OF THE PAST. THIS AREA IN THE VICINITY OF PICTURE GORGE IS DESIGNATED BY A MALTESE CROSS.

a much thicker aggregate of rock units exposed along the John Day River and its tributaries. It becomes evident, even to the casual observer who travels the John Day highway, that the entire section of strata in this region shows noteworthy differences in types of rocks. Less apparent, but readily comprehended with a little study and contemplation, are the conditions of climate and topography that must have existed when the individual formations accumulated. The sedimentary beds that contain the petrified skeletal remains of land mammals—and impressions of plant fossils in some horizons—were apparently laid down in several ways: on the land surface; in lake basins; and under fluviatile conditions.

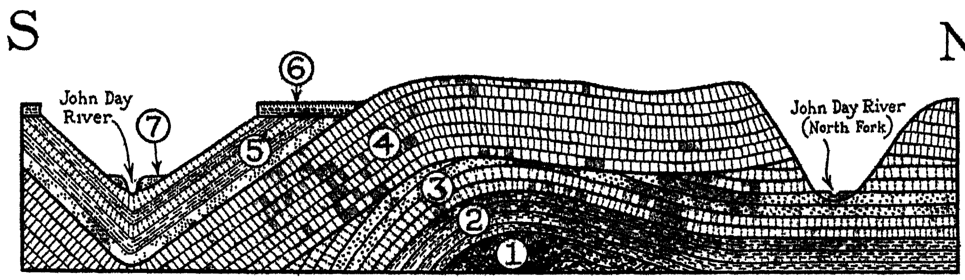
However, not all of the rocks that are seen in the John Day area originated in this manner. The Columbia basalts,

one of the most distinctive and widespread formations in the Northwest, are strikingly displayed in cross section in Picture Gorge, the canyon through which the John Day River flows, about five miles west of the village of Dayville. These rocks were once molten, and, while occasionally the charred and silicified remnants of tree trunks are found in them, no vestiges of animals have been discovered. Nor would one normally expect to find them. Again, marine deposits occur well below the Columbia lavas and are, as a matter of fact, among the oldest known strata exposed in the immediate vicinity of Picture Gorge.

Viewing the entire array of formations along the John Day River and highway from Spray southward to and beyond Picture Gorge, one is also impressed by the fact that gaps, or intervals, are present in this sequence of strata. In other words, that portion of geologic time recorded by the several rock units is not complete in the sense that the last thirty or forty millions of years of earth history is represented by an uninterrupted succession of geological formations, layer upon layer, or by a continuous sequence of life. It would indeed be remarkable were this actually the case. Instead, the periods of accumulation of sediments and lavas in this region were interrupted at intervals by earth movements of greater or less intensity. As a result, the strata that had accumulated prior to an event of this kind were folded, in some instances broken or faulted, and eroded. On the eroded surfaces were then laid down later deposits. These discordances in the stratigraphic record tend further to demarcate sharply the individual rock formations from each other and help to differentiate the fossil assemblages found in them.

The oldest mammalian fossil so far known from Oregon is a single tooth, discovered in the Clarno formation near the crossing on the John Day River called Clarnos Bridge. The Clarno deposits in this region consist of tuffs and mud flows. The specimen has been identified as belonging to an early type of rhinoceros. In the same formation occur fossil nuts, seeds, and leaf impressions.

By far the most abundant remains of fossil mammals are found in the picturesquely sculptured and often vividly colored badlands of the John Day deposits located between Spray and Picture Gorge. More than one hundred different kinds or species have been described from the John Day, the list including flesh eaters, like the true and sabertoothed cats, and a large variety of dogs, herbivores, like the horses and camels, omnivores, like the peccaries and giant pigs, and, in addition, rodents, rabbits, and an opossum. In the entire assem-



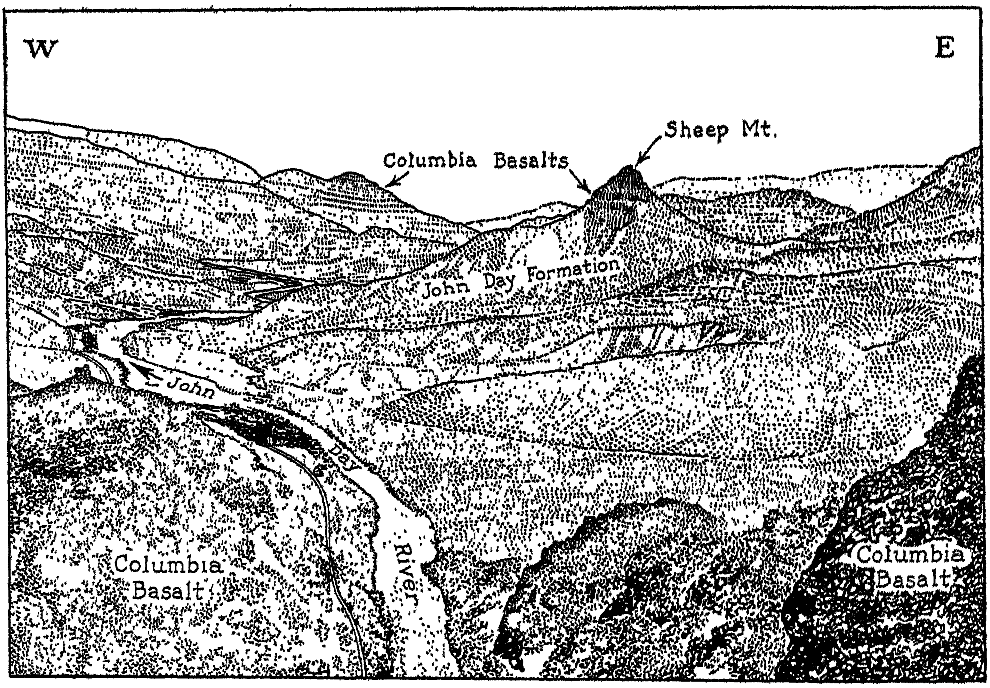
Modified after Collier

CROSS SECTION OF GEOLOGICAL FORMATIONS

A DIAGRAMMATIC AND SOMEWHAT IDEALIZED SECTION OF THE FORMATIONS EXPOSED BETWEEN A POINT NEAR PICTURE GORGE AND ONE SITUATED NORTH OF THE NORTH FORK. THEY ARE: 1, CRETACEOUS; 2, CLARNO; 3, JOHN DAY; 4, COLUMBIA BASALT; 5, MASCALL; 6, RATTLESNAKE; 7, TERRACE DEPOSITS.

blage are creatures whose characters only remotely resemble those of animals living today. Such, for example, are the ubiquitous members of a tribe of herbivorous mammals called oreodons, often spoken of as ruminant hogs. Among all the animals uncovered in the John Day by either the professional collector or the layman, these are the most common. While oreodons occur in both the green- and buff-colored deposits, differences prevail between them, and the largest specimens are found in the upper strata. In size, in proportions of the body, and apparently also in some of their habits, the oreodons show resemblance to swine and peccaries, but they differ greatly from these animals in other respects. Their teeth, to cite merely one of their structural characteristics, are not at all like those found in pigs and peccaries but are very similar to the teeth possessed by the cud-chewers.

The oreodons were distinctively North American mammals, for they not only originated on this continent, but their subsequent history and ultimate extinction likewise occurred here. Presence of mammals having no intimate blood affiliation with creatures found fossil elsewhere in the world may imply an absence of land connections between North America and other continents, as in this instance during the time of accumulation of the John Day deposits. On the other hand, there may be other equally good reasons why these animals were restricted to North America. At any rate, the evidence stands in contrast to that obtained from a later formation in the John Day area, in which instance the relationships of certain fossil mam-



THE VALLEY OF THE JOHN DAY RIVER

LOOKING NORTH FROM PICTURE GORGE. BEYOND SHEEP MOUNTAIN A PORTION OF BUTLER BASIN IS SEEN. RED, GREEN, AND BUFF-COLORED JOHN DAY DEPOSITS ARE EXPOSED AS BADLAND SURFACES ON THE FLANKS OF SHEEP MOUNTAIN. THE REMAINS OF MAMMALIAN FOSSILS ARE FOUND IN THEM.

mals strongly suggest a continental connection at that time between North America and Asia and between North and South America.

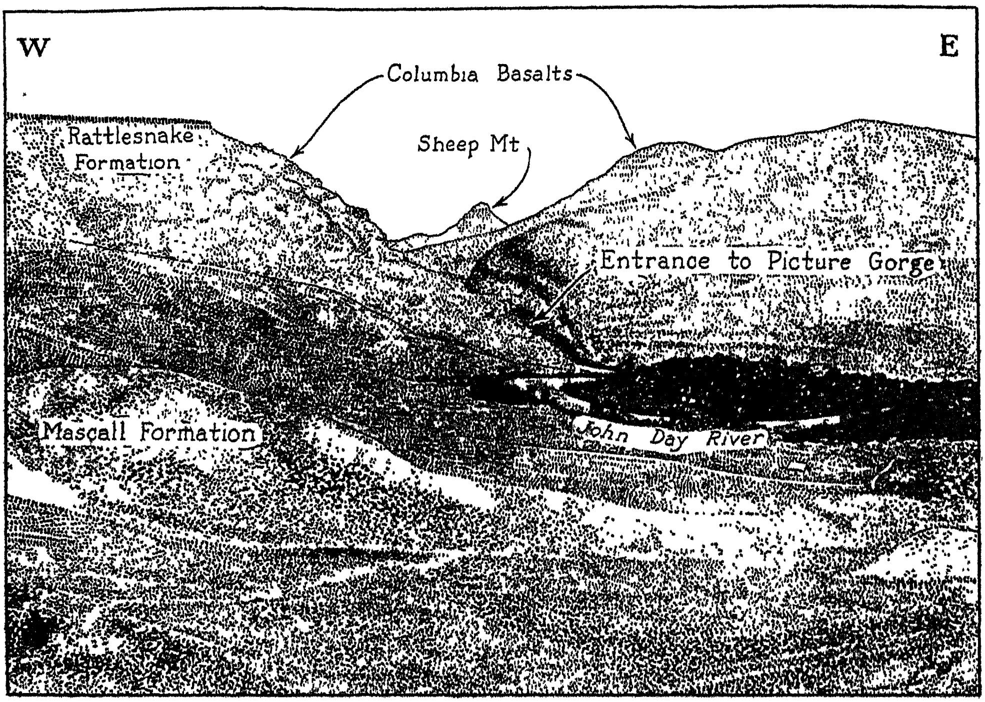
Other kinds of fossil mammals found in the John Day beds are rhinoceroses, tapirs, and camels. While these possess distinguishing characteristics of their own, they show a basic resemblance to their respective living representatives, which suggests a broad and more or less direct relationship with them. The presence of living rhinoceroses in Africa and Asia, of tapirs in Brazil and Malaya, of camels in Asia and Africa, and of llamas in South America serves to emphasize the strangeness and exotic character of the mammalian life of that ancient epoch in Oregon.

Lastly, an early member of the horse family from the John Day should receive specific mention because of its scientific and popular interest. Some especially fine specimens of Miohippus, as this primitive horse is called, have been found in the green-colored strata of the middle John Day. Our knowledge of this interesting creature is sufficiently complete to tell us that it stood about six hands at the withers, on both front and hind feet there were three well-developed toes, and its grinding teeth were short-crowned, as they are in a browsing mammal.

The lineage of the horse family, regarded by the student of evolution as an excellent example of that growth with change which organisms undergo as they evolve in geologic time, comes by this significance precisely for reasons so well demonstrated in the sequence of geologic formations of the John Day basin. For, while the oldest horse found in the John Day deposits is not the most ancient, it is a beginning member of an interesting series in which each type found in successively higher and superimposed fossiliferous formations is more advanced or more specialized than its antecedents. It is as though the horses kept pace with a changing earth, remaining not unchanged themselves, but showing in the several stages of their advance a trend to larger, more efficient types in their adjustments to earth movements, changing environments, and diminishing rainfall.

The John Day fossil assemblage could not have lived under semiarid climatic conditions like those which now exist in the area. The abundance and variety of the animal life furnish some of the evidence in support of this view. Presence of individual kinds of mammals, like the tapir, rhinoceroses, giant pigs, peccaries, opossum, certain of the rodents, browsing horses, and possibly the oreodons, may be taken to indicate the existence of considerably more verdure and thus decidedly more moisture than occur there at the present time. As a matter of fact, an abundant and beautifully preserved flora found in the lower John Day beds clearly indicates that the climatic conditions were temperate and wet.

After the entombment of this diversified life in the John Day deposits, this formation was folded and eroded. Subsequent to these events came the great episode of upwelling of basic lavas. The molten rock issued from fissures developed in the surface formations of the region and engulfed not only the John Day country but a vast contiguous area as well. The Columbia basalts lay like a pall over the buried relics of the past, and for a moment, geologically speaking, all living things were driven from the region or were destroyed. How different must have been the landscape when the existing topographic relief was shrouded by successive layers of a basaltic mantle! When, however, at the close of this important history, the outflows of lava gave way to explosive activity and ash showers, a new cycle of sedimentation was initiated, and accumulation of fos-



THE JOHN DAY RIVER AT PICTURE GORGE

ON THE LEFT CAN BE SEEN THE WHITE ASH OF THE MASCALL FORMATION RESTING ON COLUMBIA BASALT. OVERLYING THE MASCALL IS THE RATTLESNAKE FORMATION, CAPPED BY A RHYOLITE FLOW.

sil material again became possible. The Mascall formation of volcanic ash, silts, and reworked ash lies on top of the Columbia basalts, the lower strata of ash being interbedded with the upper lavas of the basalt series.

In successive horizons of the Mascall are evidences that the strata were laid down in lake basins, along the borders of fresh-water bodies, and on the land. Life again tenanted the region. Plants established themselves on the landscape, as shown by a multiplicity of leaf fossils found in particular horizons. At a certain level an earthy ash contains the principal representation of fossil mammals found in the Mascall. The known animal assemblage is not so large nor so varied as that from the John Day beds.

Predators, hoofed mammals, and smaller forms like rodents are known by fossils found in the Mascall formation. Oreodons are present, and at least one of these is more advanced than those found in the John Day deposits. A peculiar member of the deer family (Dromomeryx), which possessed curved, clublike horns, is represented by one or two fairly good skulls and some skeletal material. Remains of camels and horses are also found. One of the horses, called Merychippus, resembled a pony in size. Its feet still had three toes, but the side toes on each foot were more reduced in size than in the earlier horses collected in the John Day formation. The permanent grinding teeth, in contrast to those of antecedent types, possessed greater efficiency for chewing gritty grasses, as shown by their longer crowns and by the more complicated enamel pattern of their wearing surfaces. Students of the horse group regard these characteristics as an indication of a

progressive development in the course of which grazing habits were acquired. Other kinds of fossil horses are likewise present, but these retain more primitive characters, although they are also in advance of the horses found fossil in the John Day deposits.

The flesh-eating mammals include a huge bearlike dog and another member of the canid family that serves well as an ancestor of the modern wolves. Still another carnivore of small size found here shows a curious resemblance to the mustelids and raccoons. The mammals found fossil in the Mascall formation apparently once had a wide dispersal in southern Oregon and adjacent regions, for essentially identical animals have been recovered from sediments of Mascall age at a number of widely scattered localities in this general area. The entire assemblage, like that from the John Day deposits, reflects the existence of a moister climate than prevails in the region today. This view receives added support if in the group are included the fossil mammals collected in deposits of equivalent age at localities adjacent to the John Day basin. The browsing horses, camels, deerlike antelopes, possibly Dromomeryx, as well as some of the squirrels and members of the mountain beaver group, may all have lived under climatic conditions which were not so wet as during John Day time nor so dry as during the epoch of deposition which followed.

Subsequent to the time of entombment of this assemblage of life, the Mascall formation and the several groups of strata which lie beneath it in the John Day basin were folded. The Mascall was eroded, and on its truncated edges were laid down, at a still later time, another series of deposits called the Rattlesnake formation. These comprise gravels, tuffs, and relatively thin outflows of acidic lavas (rhyolite). The

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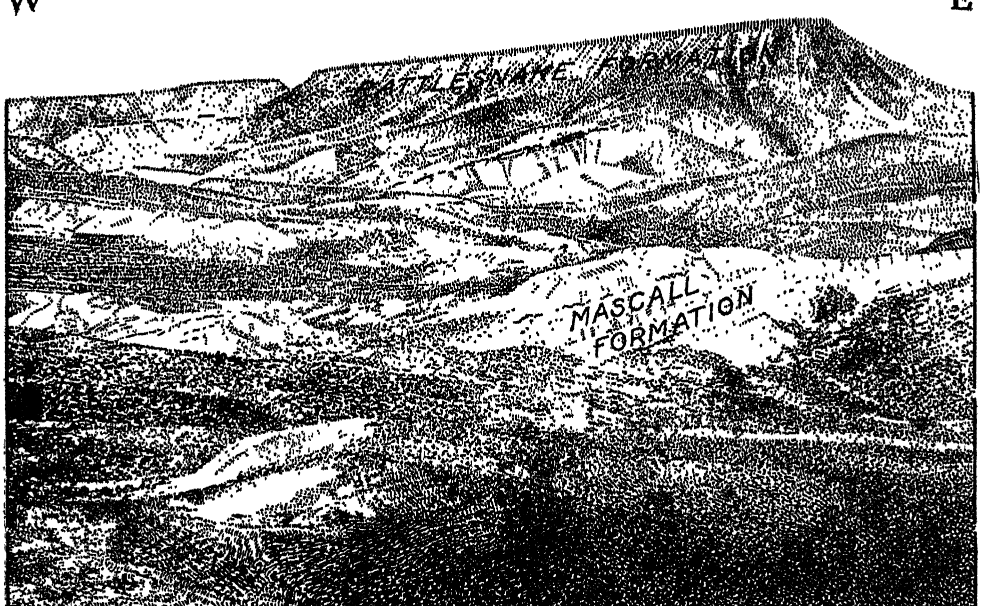

RHYOLITE-CAPPED BUTTES ALONG RATTLESNAKE CREEK

THIS REGION LIES IMMEDIATELY WEST OF THAT SHOWN OPPOSITE. THE FOSSIL-BEARING MASCALL MIOCENE IS OVERLAIN UNCONFORMABLY BY THE FOSSILIFEROUS RATTLESNAKE PLIOCENE FORMATION.

sedimentary deposits appear to be largely stream-laid. The interval which separates the Rattlesnake from the Mascall helps to demarcate sharply the two formations and the fossil assemblages which occur in them.

The fossil mammals collected in the Rattlesnake are not only entirely different from those known from the Mascall, but wherever related forms occur in both, the more advanced or progressive types are found in the upper or later formation. Within the horse group, for example, are two distinct kinds, one (Pliohippus) in the line of descent to the modern horse, the other (Neohipparion) representing a side branch destined to die out. Both, however, are definitely more advanced or specialized than the horses in the Mascall. In Pliohippus apparently the feet had reached a stage of specialization wherein only a single functional toe, the third, was present, and the side toes were so greatly reduced in size as to reach the point of complete disappearance.

Neohipparion, on the other hand, retained the side toes. As the animal stood on its median or third toe, the side toes were off the ground to at least a slightly greater extent than in the Mascall Merychippus. Then, too, both Pliohippus and Neohipparion were larger than the Mascall horses, and their grinding teeth were even better adjusted to grazing habits.

Rhinoceroses are known, and these were among the last of their kind found fossil in North America, for the group became extinct either during the time of accumulation of the Rattlesnake formation or shortly thereafter. Camels of very large size and peccaries were present, as also were relatives of the modern pronghorn antelope. Among the large and small forms can be listed mastodons, rabbits, and a squirrel. The predatory animals included cats, mustelids, an ancient coyote, bearlike dogs, and a bear. The bear is a particularly interesting creature because it closely resembles, or is identical with, a fossil bear described from northern India. This intimate relationship between two forms so widely separated geographically is some of the evidence regarded by students of American fossil mammals as implying that North America and Asia were joined by land at a time when these animals were in existence. A similar case is presented by the occurrence of remains of extinct ground sloths in the Rattlesnake deposits. In this instance, the appearance of creatures with South American affinities in the Rattlesnake and absence of comparable mammals of southern origin in earlier fossiliferous horizons furnish a clue to the time of establishment of migratory routes for land animals between the two continents.

The record of many grazing horses and an absence of browsing kinds in the Rattlesnake, as well as presence of grazing antelopes and large camels, suggest that the environmental conditions then were somewhat like those that exist today on the central high plains or on the high plateaus of the Far West. That the area was not all grassland and that wooded regions were also present is suggested by the occurrence of rhinoceroses, mastodons, and peccaries. But a survey of the entire fossil assemblage leaves the impression that the climatic conditions at the time of existence of these animals were considerably more arid than during the period of accumulation of the John Day sediments and also drier than during the time of the Mascall deposition.

In the vicinity of Picture Gorge, where it is seen to best advantage, the Rattlesnake formation shows definite signs of disturbance by earth movements. These, however, were not so severe as were those that folded the strata of the John Day basin at times prior to the deposition of the Rattlesnake.

The last stage in the history of life of the John Day area, before the coming of Recent time, is recorded in terrace deposits now exposed along the present stream courses. In comparison with the earlier fossil assemblages, this unfortunately is a meager one, for it comprises only extinct species of elephants and an equine essentially similar to the modern horse. In at least the latter instance fossil evidence indicates that the earlier mammals continued in their evolution to higher, more advanced, or more specialized kinds. This last member of the horse group is clearly separable from the fossil equines found in the Rattlesnake formation. In stature and apparently in those specializations of bodily construction to which attention has been directed before, it shows a definite step forward beyond its nearest relatives occurring in the Rattlesnake. In these characteristics it shares its exalted position with that tried and useful servant of man, who today gives patient service before hayrick and harrow in the valley of the John Day.

Reviewing these chapters in the geologic history of the John Day basin, the student of the earth sciences comes to appreciate the individuality of the several rock units exposed there, the relationships which exist between them, and the fossils which they contain. In determining the super-position and sequence of these strata, the geologist ultimately comes to integrate this local history with that written in other areas. He establishes a more or less standard scale whereby all geologic history is recorded with reference to the passage of time. In the present instance, the specific events fall into geologic epochs recognized under an accepted terminology of universal application. Thus the Clarno formation is assigned to the Eocene, the John Day formation and its fossils are referred to the Oligocene and Miocene, the Columbia lavas and the Mascall to the later Miocene, the Rattlesnake to the Pliocene, and the terrace deposits to the Pleistocene, or Ice Age.

But in the larger sense the geological story, here outlined for the John Day basin, demonstrates effectively the mutability of earth and of the living things upon it. In shifting scenes of the same region are glimpsed the changing surface features of the earth, various ways in which geologic formations are laid down, and alterations in climate during certain stages of the Age of Mammals, wherein the direction of change is from moist to drier conditions. In such unstable surroundings it is perhaps not surprising to find that life likewise becomes modified. With elapse of time not only do old forms disappear and new forms appear, but where particular lineages among mammals can be traced, there is definite evidence of evolution.

The movement of life upward through the ages seems to be accompanied by a change from the general to the particular, from the primitive to the more advanced, from a state of more or less efficiency or of specialization to one of greater efficiency or specialization. Not all lines of development among the fossil mammals carry on into the present (many become extinct along the way), but the life of today is unquestionably an outgrowth of that of the geologic past. While the story of this life possesses much of local interest, certain facts stand revealed which, when placed in proper relation to others, take on added significance in time and space. Like the missing piece in a mosaic that falls into position and illumines thereby the larger meaning of its own design, so also, when joined with others, does an isolated fact derived from the fossil record often make clear its wider import in history.

THE WESTERN MUSEUM SOCIETY OF CINCINNATI

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CINCINNATI was one of the earliest centers of scientific activity in the Middle West. There, as part of the growth of the city in the early nineteenth century, two pioneer natural history societies were founded, the Western Museum Society in 1818, and the Western Academy of Natural Sciences in 1835. In the establishment of these two institutions there was being repeated the experience and practice of the older cities of the United States. In Charleston, Philadelphia, New York, Boston, and other places natural history study groups had been organized during the eighteenth century, and collections of plants, rocks, minerals, fossils, and birds and animals had been made. These societies and museums had come into being as the cities began to emerge from the settlement period and as a few fortunate citizens began to prosper financially. With this surplus of wealth over the demands of mere livelihood, the "upper classes" provided themselves with more luxurious homes and beautified the grounds around them. Having taken care of themselves materially, men indulged in intellectual and cultural pursuits, and natural history was a favorite hobby of eighteenth century gentlemen. They also exhibited a social conscience and were the patrons and financial supporters of libraries and schools for the improvement of the masses.

Schools, libraries, dramatic and debating societies, literary circles, and natural history societies of the eighteenth and early nineteenth centuries were developed largely because of the need for self-improvement felt in a new country. With no one but themselves to depend on, men provided educational, scientific, and cultural advantages for their communities through mutual cooperation and voluntary association.

As Ralph S. Bates in his recent study *Scientific Societies in the United States* (New York, 1945), William M. Smallwood in *Natural History and the American Mind,* and Carl and Jessica Bridenbaugh in their detailed account of Philadelphia *Rebels and Gentlemen* (New York, 1942) have all demonstrated, the advanced study of natural history and of science in general has been carried on chiefly in cities, and the foundation of scientific societies is essentially a part of the process of urban growth. A chart in Dr. Bates' book shows that the establishment of local scientific societies followed the movement of population westward. As natural history societies and academies of science were founded in the eastern cities in the last decades of the eighteenth century and the first two or three decades of the nineteenth, so in the 1830's, 1840's, and 1850's they were founded in Cincinnati, Cleveland, St. Louis, Chicago, and other cities of the Middle West as they outgrew their pioneer crudities and strove for the habiliments of civilization.

It is my purpose to illustrate the foregoing ideas by a study of the Western Museum Society of Cincinnati. The Western Academy of Natural Sciences was the first academy of science in the Mississippi Valley, and it has an interesting history. But the Western Museum Society attempted to do more than simply maintain a museum, and its his-

tory sufficiently illustrates the principles here set forth, although it was two decades in advance of the general movement.

While it is generally true that scientific societies, academies of science, and natural history museums were a product of city growth, certain other conditions were necessary. Economic success and population increase but prepared the soil. Individuals with enthusiasm and financial resources were necessary for the planting of the seed and its propagation. Those who first became interested in natural science were the doctors and schoolteachers. These came together to exchange ideas and frequently brought within their circle businessmen who had established their financial security and engaged in natural history as an avocation. From among the latter the money for the support of scientific research was obtained. In Cincinnati the man who started the Western Museum Society of 1818 and the later Western Academy of Natural Sciences (1835) was Daniel Drake, physician, author, businessman, and scientist. He provided both the initial stimulus and a portion of the financial backing for the Western Museum Society and organized the Academy.

Daniel Drake was a product of the Kentucky-Ohio frontier. Born at Plainfield, N. J., October 20, 1785, he was taken by his family to Kentucky when he was three years old. Near Maysville, his father, who is said to have arrived in the community with only $1.00 in cash, took up a small farm. He prospered and in 1794 acquired two hundred acres of land, much of it virgin forest. Young Drake thus experienced pioneer life as a farm boy but with an unusual sensitiveness to his surroundings. His biographer says that Daniel "looked upon all the elements and incidents of his early life in the woods with the fancy of a painter and the emotions of a poet." (There is no modern biography of Drake, and all sketches of his life, including that in the *Dictionary of American Biography,* by Albert M. Matthews, are based on Mansfield's *Memoirs.*) Receiving the usual meager schooling of the early settler, Drake was eager to learn and devoured such reading material as he could lay hands on. A cousin, John Drake, was a doctor, and it was planned that Daniel should study medicine with him. But John Drake died, and, after a family consultation, Daniel was sent off to Cincinnati as an apprentice to William Goforth, a leading physician of that city. By the time Daniel was nineteen he had progressed so far that Dr. Goforth accepted him as a partner, and the young man actively visited patients and prescribed medicine for them. But Drake knew that if he were to reach the heights of his profession, he should have training in a recognized medical school. In 1805 he went to Philadelphia to the University of Pennsylvania where he was under the tutelage of Dr. Benjamin Rush and other leading physicians. After his stay there he practiced medicine for a short time at Mays Lick, Ky., and returned to Cincinnati on April 10, 1807.

The city in which Drake decided to make his permanent home was experiencing a business boom that came from the accelerating movement of settlers into the Ohio Valley. Drake, certain that Cincinnati had a great future, began to take an active part in community activities. He became a member of a debating society, took part in amateur theatricals and in other efforts toward self-improvement. He married Harriett Sisson, a niece of Colonel Jared Mansfield, in the autumn of 1807. Colonel Mansfield, a mathematician and scientist, was at this time Surveyor-General of the United States and directed the land surveys in the old Northwest. He later became professor of natural and

experimental philosophy at West Point. On his farm at Ludlow's Station, near Cincinnati, the young and progressive leaders of the community congregated for social intercourse. And at the farm and in the course of his daily calls on rural patients, Drake pursued an already awakened interest in natural sciences. He opened an Indian mound and described the pottery and human remains; he collected plants and prepared a catalogue of those useful in *materia medica;* and he kept meteorological readings.

The result of this scientific study was a pamphlet *Notices of Cincinnati, Its Topography, Climate, and Diseases,* written in 1810 and expanded in 1815 as a book *Picture of Cincinnati and the Miami Country.* This famous work had a large circulation in the United States and in Europe. It embraced a description of the geography, population, aboriginal anthropology, and natural history of the Ohio country, as well as the political and judicial organization of the city, county, and state, and a discussion of the diseases of the people of the West. It ended with an account of the great earthquake of 1811–12.

Meanwhile, Drake was taking advantage of the opportunities for making money in business. He opened a drugstore, later selling it and transferring his attention to a general store for the sale of groceries, dry goods, and hardware. He also became a stockholder in a textile factory, the Cincinnati Manufacturing Company. In the period of business optimism immediately following the close of the War of 1812, American merchants were enthusiastic about the profits to be made from the resale of the cheap British merchandise that was being dumped on the American market. Drake decided to purchase goods for his store in the nearest port, Philadelphia. But the doctor had other purposes in mind, also. He wanted to secure his M.D. degree, study medical schools, and investigate the cultural and scientific life of the city. In the few months he was in Philadelphia in 1815 he visited museums, attended medical lectures, and met the scientific and literary leaders at meetings of the American Philosophical Society and of the Academy of Natural Sciences, and in the homes of such men as Dr. Caspar Wistar, president of the American Philosophical Society.

One of Drake's consuming passions throughout his life was the teaching of medicine, and, after his visit to Philadelphia and another year in Cincinnati, he accepted an invitation to become a member of the first faculty of the Medical Department of Transylvania University. But Drake was not satisfied with Lexington as a place to live. As Mansfield says, he aspired to be an eminent citizen as well as an eminent physician and scientist, and Cincinnati was rapidly becoming the Queen City of the West. Drake therefore returned in 1816. Writing at that time, he expressed his enthusiasm for the budding metropolis:

> Cincinnati continues to advance. This is so strikingly the case, that if you were here, you would perceive in its present aspect, a great contrast with what it had exhibited six years ago. Two steamboats have been completed at this place within the last eight months, and seven more are now on the stocks. The engines for them and all the iron machinery are made at an extensive iron foundry between our old house and the river. The town generally has undergone great alterations. All the principal streets will in a short time be paved. A horse ferry-boat had been built, and greatly facilitates our intercourse with Newport and Covington. Our two old newspapers have been enlarged to imperial size, and a third will be commenced on Tuesday next.

Again he wrote:

> There are also at this moment, arrangements making in Cincinnati that will render its institutions, at no distant period, as superior to those of any other town in the West, as its population and trade are pre-eminent. During the last week $29,000 were subscribed by seven gentlemen [Drake was one of them] as a permanent fund for the Lancaster Seminary.

Within the same week a site for a poor house has been purchased, in a suitable situation, and the establishment has been planned in a manner that will make it a hospital, the only desideratum to the formation of a medical college in this place.

The Lancaster Seminary was the forerunner of Cincinnati College, now Cincinnati University. It had been founded in 1815 by Dr. Joshua L. Wilson, pastor of the First Presbyterian Church, with Drake as an enthusiastic backer. Drake was also working toward the establishment of the Medical College of Ohio, which opened its doors to students in 1821 and he was one of the founders of the Library Society in 1813.

Library, medical school, hospital, college—Philadelphia had all these, plus museums and scientific societies. Cincinnati must have them, too, and Drake called a public meeting to promote the establishment of a museum. He wrote:

A Society has been formed, and I confidently expect to see from $5,000 to $6,000 contributed to that object next week. I have drawn up the constitution in such a manner as to make the institution a complete school for natural history, and I hope to see concentrated, in this place, the choicest natural and artificial curiosities in the Western country.

Thus, as a part of the cultural requirements of a great city was inaugurated the first organized effort to promote the study of natural science in the Middle West.

The constitution prepared by Drake provided that memberships should be sold for $50 and that the subscriber and his family should have free admission to the museum at all times. Five "managers" were named to secure contributions and to take care of the collections as they accumulated. The first managers were Elijah Slack, President of Cincinnati College, James Findlay, lawyer and editor of the newspaper *Liberty Hall and Cincinnati Gazette,* Jesse Embree, William Steele, and Drake. They published in 1818 "An Address to the People of the Western Country" in which they said that their first efforts would be directed "to the establishment of a permanent museum, on a scale so comprehensive as to receive specimens of every curious thing which they may be able to procure." It was their intention to accumulate four classes of objects:

1. Metals and minerals generally, including petrifactions.
2. Indigenous animals, embracing the remains of those which are now extinct.
3. The relics of the unknown people who constructed the ancient works of the western country.
4. The various articles manufactured for use by the present savage tribes.

Later the "promotion of the useful and ornamental arts" was made one of the society's objectives.

In July 1819, the Museum Society apparently had sufficient exhibits to begin regular meetings, but the museum was not formally opened until 1820 when its collections occupied rooms in the Cincinnati College building. At that time its exhibits and "philosophical apparatus" were valued at $4,000. The acquisition and preparation of specimens was in the hands of the managers and appointed curators. There were at least three of the latter. One was Joseph Dorfeuille, a wandering French naturalist and showman of uncertain antecedents. His special scientific interest was the natural history of insects, and as a result of collecting activities along the lower Mississippi he published two papers on entomology in the *Western Quarterly Reporter of Medical, Surgical, and Natural Science.* After the temporary closing of Cincinnati College in 1825 the collections of the Museum were placed in his care, and he displayed them along with his popular exhibits of antiquities, curiosities, and wax figures. Dorfeuille's museum was long a favorite place for entertainment in Cincinnati. He later went to New York where he maintained a show of wax figures while preparing a

work on "Antiquities of America." The manuscript remained unpublished when he died in 1840.

Robert Best, a young chemist and physicist who was Slack's assistant at Cincinnati College, was also a curator. His particular task was to make "philosophical apparatus" to "illustrate the principles of magnetism, electricity, galvanism, mechanics, hydrostatics, and the mechanism of the solar system." John James Audubon was associated with the museum as taxidermist for a few months in 1819–20 because of his skill in "stuffing fishes." Drake recognized Audubon's talent as a portrayer of birds but praised Alexander Wilson as the foremost American ornithologist.

Daniel Drake, however, was the guiding genius of the Western Museum Society. In 1819 and 1820 at the annual meetings of the members he delivered "anniversary discourses." In spite of the many self-improvement enterprises in which the people of Cincinnati were engaged, their first concern was the business of getting ahead in the world. They recognized in principle the desirability of developing the cultural life of their city but they frequently lost their initial ardor after the first burst of enthusiasm. Drake recognized that there was a tendency to backslide, and in his discourse of 1820 he said that there were two imperative reasons for commemorating the establishment of the Western Museum Society.

> First: At the expiration of the two years which have been spent in the collection and arrangement of curiosities, when they are prepared for public inspection, and the doors of the Museum are about to be opened, it is important that we should review the design and labors of the Society, and inquire what benefits they are liable to produce. Secondly: as the arts and sciences have not hitherto been cultivated among us to any great extent, the influence which they are capable of exerting on our happiness and dignity is not generally perceived, and they have consequently but few friends and admirers. It is therefore proper, that we should institute and continue to observe an annual festival in celebration of a Society established expressly for their promotion; that we may elevate their character with the mass of our people, and multiply the number of their devotees and patrons by the infallible method of augmenting their consequence.

Drake saw the Western Museum Society as an important and indispensable means of understanding and developing the natural resources of the Middle West:

> The plan of our establishment embraces nearly the whole of those parts of the great circle of knowledge which requires material objects, for their illustration. . . . Already, indeed, in the possession of many specimens in Zoology, Mineralogy, Antiquities, and the Fine and Useful Arts, we venture to indulge the hope, that even at this time, we can offer *something* to interest the naturalist, the antiquary and the mechanician.

But, said Drake, unless the collections were arranged in order according to the "most improved systems," such a body of substances as had been gathered would "neither gratify the curiosity, nor inform the understanding." This, however, was an objection "rather specious than solid," because it is in a new country that such a "multifarious assemblage is most proper." Older communities could have specialized cabinets and museums, but "young societies" must have general collections because everything is new and unsorted and unclassified. "Let no one, then, charge our Society with temerity for aiming at a general collection; nor regard as an evidence of vainglory and undisciplined ambition, what in reality, is both the effect, and indication, of our recent settlement in a new region."

In 1820 the Museum's holdings were little more than a cabinet of mineralogical and lithological specimens, examples of Indian handicraft, and relics from Indian mounds, but by 1823 the Museum had

> 100 mammoth and Arctic elephant bones, 50 Megalonyx bones, 33 quadrupeds, 500 birds, 200 fishes, 5000 invertebrates, 1000 fossils, 3500 minerals, 325 botanical specimens, 3125 medals,

coins and tokens, 150 Egyptian and 215 American antiquities, 112 microscopical designs, views of American scenery and buildings, tattooed head of a New Zealand chief and about 500 miscellaneous specimens of the fine arts and an "elegant organ." Drake painted a bright future for the Museum.

He saw it as a place for research into the habits and classification of the birds and animals of the Middle West. It was to be an institution for the study of anthropology and a laboratory in which experiments in natural philosophy might be conducted. He said it would be a means of education for the mass of the people, and declared that, as a new nation based upon the principles of freedom and democracy, our future would be determined by the way literature and science were studied, for it was from these that we would acquire "refinement and elegance" and "progress in the mechanical and chemical arts."

Finally, he urged his fellow-citizens to support the Museum Society and aid it in attaining its objectives. In peroration he said:

If we perceive, then, in the increase of useful knowledge the true secret of our permanent happiness; if literature can supply the talismanic agent of our prosperity, like a "pillar of fire by night," direct our wandering footsteps to the temple of glory, let us not ignobly stay our hands from the labors by which, only, philosophy and letters can be made to flourish. Let the architects of our national greatness conform to the dictates of science; and the monuments they construct will arise beautiful as our hills, imperishable as our mountains, which tower sublimely above the clouds.

Daniel Drake expected too much of the Western Museum Society as a promoter of scientific knowledge. Although Cincinnati was the leading center of cultures west of the Alleghenies in 1818, nevertheless the level of scientific knowledge there was not equal to that of the eastern centers at the same time. It was above that of other Middle Western centers, but, like them, its primary concern was the winning of economic security for its citizens. Drake and a few others were familiar with the general story of natural science. The work of Cuvier, Thomas Say, Alexander Wilson, and others was recognized. Drake was a corresponding member of the American Philosophical Society and the Academy of Natural Sciences of Philadelphia, the two most important disseminators of scientific information. The new *American Journal of Science and Arts* also had its readers in Cincinnati. The first strictly scientific publication in the Middle West was the *Western Quarterly Reporter of Medical, Surgical and Natural Science,* published in Cincinnati. The two volumes that appeared had articles by Cincinnatians J. P. Foote, James Flint, and Joseph Dorfeuille. Whether the Western Museum Society inspired these writers or whether their interests was a factor in the foundation of the Society cannot be determined. It is significant, though, that individuals were thinking about natural science, and that they joined together to stimulate general enthusiasm for natural history study.

The Western Museum Society flourished but a few years and never reached the goals set for it by Drake in 1820. Drake's personal interest flagged when he became involved with the organization and promotion of the Medical College of Ohio, fought a losing battle with his fellows on the faculty for control, and left Cincinnati for a place in the Medical Department of Transylvania University. He did not return to Cincinnati until 1827. The business decline that began in the East in 1819 hit Cincinnati about 1821, and Drake and others suffered financial reverses. Cincinnati College, too, was affected and had to close its doors in 1825. All these things together cut short a most promising, if overly ambitious, endeavor to promote the study of natural science in the Middle West.

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SCIENCE ON THE MARCH

VICTORY ON THE POTATO FRONT

POTATOES are weapons of war. This is the story of how a lowly but dangerous fungus helped to defeat Germany in two wars, how it backfired, threatening American food production, and how modern science has brought new discoveries to bear on the century-old problem of controlling the potato blight fungus, cause of famine and migration.

Just a hundred years ago, with the fury of an atomic explosion, the murrain, or blight, first swept across a million acres in England and Ireland, leaving a devastation of foul, rotted potatoes, bringing death from starvation and disease to a quarter-million Irish farm folk or driving them to migrate away from the blight-cursed potato fields—to America.

Most people believed that the blight was a mysterious Visitation of God, something beyond the grasp of mortal minds, but the scientists of those days thought differently, and soon the brilliant young German botanist Anton DeBary proved that the blight is the work of a microscopic mold fungus, a living parasite of the potato plant.

Too late to save the victims of the potato disease epidemic, a temporary remedy was found—Bordeaux mixture spray—and until recently this has been the potato grower's only defense against the ever-present danger of ruin from blight. Shortage of labor and spray chemicals let down the bars against the blight fungus in both world wars. In wartime potatoes are essential both for food and industrial alcohol. Their production is sorely handicapped by wartime lack of fertilizers, of farm manpower and machinery, and even lack of land that must be devoted to other purposes. When to these handicaps is added that of desolating plant disease, the resultant crop shortage becomes a major factor in turning the tide of battle.

Germany lost the first World War chiefly because of her food shortage. There the potato is the chief source of carbohydrate, and many Germans remember the terrible "turnip winter" of 1917–18 after blight had destroyed the potato crop and the war had to be waged on a diet of turnip soup, baked turnip, turnip pie, and grass-root "coffee." Again in World War II there was a potato famine in Europe, and although we do not yet know all the circumstances leading to the potato shortage, there are indications that blight was again on the rampage, sabotaging the Axis' crops.

But the potato blight fungus is no partisan. The potato fields of the Allied nations also bowed under the vicious attacks of the dreaded disease in both wars. The 1916 potato crop in the United Kingdom was one of the poorest on record, but a well-organized spraying campaign in Ireland throughout the war salvaged a million tons that would otherwise have been sacrificed to blight. The lesson had been learned, and when in 1943 England was again visited by "one of the worst blight years in living memory" spraying increased yields by 25 percent.

Nor did America escape. The mildness of blight attacks in 1940 and 1941 lulled growers into a false feeling of security, and they were not prepared for the unparalleled blight blitz of 1942 that destroyed 25,000,000 bushels of the crop and extended far to the West and South, in areas where it had never before caused damage.

Here was a challenge to our agricultural scientists, and, undismayed by the

fact that no great progress had been made against the fungus in many decades, they took up that challenge with the same will as their brother scientists working on war chemistry, aircraft design, and munitions development. And it was well they did, for 1943 again brought a severe general blight epidemic; in 1944 there was some relief in the North, but the disease was the worst ever in parts of the South; and the crop of 1945 was exposed to another lashing outburst even in the Great Plains where blight had never before been injurious. But thanks to research, scientists and growers were ready for these outbreaks. Threatened disaster was averted, and discoveries were made that promise complete control of the blight fungus for the future. Here are some of the points of attack on the problem.

Blight is erratic in appearance. There may be several years in which the disease fails to appear. During those years it is wasteful to spray the crop. Danger seems far away until growers are stirred to action by the sudden reappearance of blight in all its destructiveness—too late to save the crop. If there were only some way to know in advance that an epidemic is imminent! That was the point of attack used by Dr. I. E. Melhus, of the Iowa Agricultural Experiment Station.

The blight fungus is always around, waiting for a chance to start operations in a big way. Dr. Melhus' careful study of the relationship between temperature, rainfall, and blight during many years past showed that following certain weather conditions blight inevitably breaks out. These conditions include subnormal temperatures and excessive rainfall early in the life of the potato plant, weeks before the disease becomes apparent.

In 1942 Dr. Melhus organized a "Forecasting Service" which included many observers dotted about the main potato states, widely scattered test plots planted with infected potatoes which would react sensitively to "blight weather," and a clearinghouse of weather and blight reports, where the approach of an epidemic could be charted from day to day, much like the British aircraft warning service.

In 1943 evidence was obtained well in advance that blight was active. Weekly blight forecasts and spray warnings were issued by radio, press, and mail. In some areas the epidemic developed into one of the worst in 25 years, but growers were ready for it and hurried to the fields to put on the lifesaving coating of spray before the damage was done. Spray machines and supplies were rushed to the threatened areas, and many millions of bushels of potatoes were saved from certain destruction.

Bordeaux mixture spray takes copper, a war-vital material. The supply available to farmers became scarce. What good was a spray warning if spray material was not available? Again scientific know-how came to the rescue. Drawing on their backlog of accomplished experiments and conducting new ones, plant pathologists disclosed a number of new, potent fungicides that contain no war-scarce metals.

One of these, known to chemists as sodium ethylene bisdithiocarbamate but which farmers prefer to call "Dithane," proved to be an excellent potato fungicide in such widely separated states as Maine, Colorado, New Jersey, and Wisconsin. In Texas it increased potato yields from 80 to 242 bushels per acre and in Florida it completely outclassed Bordeaux mixture, giving yields 60 to 100 bushels per acre higher than those from Bordeaux-sprayed fields, bringing in $1,500,000 of extra cash to south Florida growers.

Along with the problem of spray materials there was a critical shortage of spray machinery, and the solution of that problem is a testimonial to the ingenuity of county agents and other agri-

cultural advisers in getting the greatest possible use out of existing equipment. One of the most successful methods of stretching spray equipment was the organization of "spray rings."

In the work of the spray rings, large sprayers operate on a cooperative or contractual basis to get the greatest sprayed acreage out of each spray rig. Each farmer of the ring contracts for the spraying of a given number of acres for 3 years, and at the proper times, indicated by spray warnings and following the recommendations of the agricultural experiment stations, a skilled operator puts on the needed applications. Besides conserving equipment, growers have learned of many additional advantages in this method of handling the spray problem. It is often cheaper than for each farmer to do his own spraying, the large sprayers are more efficient than small ones, there is no interruption of the farmer's other work, and maximum protection of the crop results from having the job well done at the right time.

In Pennsylvania 100 spray rings, spraying 16,000 acres on 2,300 farms, sprayed more than one-tenth of the state's potato acreage. Had there been a sprayer on each farm instead of the 100, it would have required 2,224 more tons of steel, the same number of pairs of tires, and over half a million more man-hours of labor to do the work. New York soon followed Pennsylvania's example, and in 1944 the number of spray rings doubled that in 1943. The idea is rapidly spreading in other states, and the scope of the work is being extended to include custom potato digging. Spray rings, saving the small grower the cost of idle equipment, are here to stay.

One of the most damaging aspects of blight is the storage rot that develops in apparently sound potatoes from blight fields. In the winter of 1943–44 one-fourth of the Maine crop rotted in storage, chiefly because of blight, in the greatest crop shrinkage in memory, and potatoes that were shipped out in supposedly good condition arrived at their destinations showing much decay.

This storage rot is the work of the blight fungus, which is washed by rain water down the stalks of potato plants just before digging time, making itself a foxhole in the tubers, sometimes without any external signs of disease. The problem was to find some way of blocking that downward migration of the fungus from diseased leaves to still healthy tubers.

The blight fungus cannot survive on dead leaves. Why not kill those vines after their food-gathering work is done? The new weed-killing chemicals provided the answer, chemicals such as "Sinox" and "Dowspray 66." The vine-killers are living up to expectations. Tests in Maine, for example, showed that tuber rot was reduced from 40 or 50 percent to 3 percent by killing the vines with Sinox. Slightly infected seed tubers are a principal means by which the blight fungus survives from one crop to the next, and an important effect of vine-killing is to reduce the number of infected seed tubers which would endanger next year's planting. Other advantages are observed: the "artificial frost" produced by the vine-killers makes digging easier, permits earlier harvesting to obtain the advantage of high prices for new potatoes, and avoids the development of secondary, offtype, and oversized tubers.

But the blight fungus has still another way of getting through the winter. Scientists Reiner Bonde and E. S. Schultz in Maine discovered that the potato dump pile, where cull potatoes are thrown, is a reservoir of infection for the fields next spring. Many of these cull potatoes are infected with blight, and some of them survive the winter and sprout early in the spring, sending up young shoots that are heavily laden with the pale white spores of the fungus.

These will often be wind-borne to nearby potato fields and start the infections that soon sweep across whole communities. There were some 6,500 dangerous dump piles in Aroostook County alone, and the Maine growers took action. They got a law passed making it an offense to allow dump piles to threaten their crops. Posters advertised the danger; thousands of farmers signed pledges to do away with the dump piles by burning or burying them or feeding the potatoes to livestock. Here again the new weed-killers came into use: they can be used to keep down the sprouts even when the dump pile is not destroyed. The practice of destroying the dump piles soon spread to Wisconsin, Colorado, and many other states, and it was learned that this not only does away with a main source of blight, but also destroys other diseases and insects, including the potato bug, which breed in dump piles.

But perhaps the greatest accomplishment of the present and hope for the future lies in developing new types of potatoes that refuse to give in to blight and resist attacks by the fungus. Maine growers alone spend $1,000,000 a year for spraying. A blight-resistant potato variety would save money, labor, machinery, and spray chemicals in time of war scarcity and lighten the economic burden of the potato grower in peacetime.

For a number of years potato breeders had been pioneering along this line with outstanding results just in time for needed war-crop production. New blight-resistant potato varieties such as "Sebago" and "Sequoia" are meeting with widespread approval for their quality and productiveness as well as their disease resistance. These are not immune from blight but suffer much less than the other varieties and permit a greatly reduced spray schedule. "Sebago," which compares with "Green Mountain," is called the best late potato for Wisconsin and has performed well in Maine, New York, Florida, Michigan, Minnesota, and western Washington. Recently, however, "Sebago" has shown signs of losing its resistance to blight, and still more highly resistant or immune varieties are needed. Breeders have been aware of this, and New York bred varieties that are fully immune from blight, such as "Empire," "Placid," "Virgil," "Chenango," and "Ashworth," adapted to different regions, will be available in very limited quantities this fall.

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BOOK REVIEWS

MORE ABOUT CINCHONA

Cinchona in Java: The Story of Quinine. Norman Taylor. 87 + vi pp. Illus. $2.50. Greenberg, New York. 1945.

POPULAR interest in quinine has grown rapidly since the Japanese attacked the East Indies. Taylor's small book, addressed to the interested layman, attempts in seventy-nine pages of easy reading to give the nature of the "hidden scroll" of malaria: its cause, the discovery of quinine, British and Dutch attempts to establish a quinine industry in India and Java, respectively, and the history of final success in Java. This undocumented story (provided, however, with a selected bibliography) is hardly an improvement upon the several other brochures in this field. Too frequently Taylor circumnavigates the subject without attempting a beach-head. The distribution of cinchona in its native Andes is indicated only in a highly generalized map. Its ecology, even in Java, is vaguely treated. Some readers would like to know more of the circumstances surrounding Dr. Laveran's discovery of Plasmodium in 1800 at Constantine, Algeria. Occasional sentences contain a confused medley of ideas. Witness: "Man, the mosquito, and malaria are mere incidents in the life history of an organism that needs our blood for food, uses the stomach of a mosquito to complete its sex life, and in the process causes the most devastating disease known to science." When we remember that Plasmodium "is neither a fungus nor a bacterium" but "an unicellular organism not so distantly related to amoeba," it is engaging to read that the "gametocytes, in the stomach of a mosquito, complete the sexual act." With reference to Taylor's point about the misspelling of the generic name *Cinchona* by Linnaeus (instead of using the historically more accurate form *Chinchona*), it may be recalled that Linnaeus intentionally altered certain commemorative generic names—e.g., *Swertia, Boerhavia,* and *Valantia*—to render the personal names into more pleasing Latin. The best chapters, amounting to about one-third of the book, treat of the history of the introduction of cinchona into Java and its cultivation there. There is a very general account of Javanese agricultural practices by the agricultural chemist, Dr. Pieter Honig.

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MEDITATIONS ON MALARIA

A Malariologist in Many Lands. Marshall A. Barber. 158 pp. $2.50. University of Kansas Press. Lawrence. 1946.

MUCH has been written on the subject of malaria, but seldom in as entertaining a fashion as in *A Malariologist in Many Lands.* Dr. Barber's reminiscing leads the reader through several of the most malarious regions in the world, including Malaya, equatorial Africa, India, the Philippines, parts of southern Europe, Russia, and Central and South America. In each region he surveys the surrounding topography, highlights the significant features in the life histories of the more important mosquito vectors, and discusses the human factors affecting disease incidence and local control procedures. One theme predominates, and that is that people must have a clear understanding of the means of malaria infection if control is to be achieved.

My experience with many malaria-scourged peoples has persuaded me that if only one could convince people that mosquitoes carry malaria and teach them a few simple means of protection, a vast proportion of the disease would disappear almost overnight.

There are few enemies of health more dependent on human shortcomings than malaria. . . . (150).

Dr. Barber's experiences have led him to express himself on problems of wide public interest, For example, a question commonly raised during the war was whether the incidence of malaria in the United States would not increase following the return of thousands of parasitized soldiers from the South Pacific and other malarious areas. Evidence of general concern is not surprising when it is realized that over 90 percent of the initial combat troops landing in parts of the Solomon Islands contracted the disease and for the most part are still harboring parasites today. However, because of our improved medical treatment and increased knowledge of the disease and its prevention, Dr. Barber believes that there will be no outbreak of epidemic malaria in the United States as the result of World War II.

In a narrative of this sort one expects to be entertained by anecdotes, and the reader will not be disappointed in this respect. The solution to the mystery of the poisoned guests is but one example of the amusing recollections of a medical detective tracking down the sources of disease. In many instances Dr. Barber's assignments were in fields unrelated to malaria, but somehow mosquitoes and malarial parasites always commanded his first attention. The story of his travels and experiences is at once both informative and of general human interest and should prove attractive to laymen and experts alike.

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SCIENCE FOR THE LAYMAN

Atomic Energy in War and Peace. Gessner G. Hawley and Sigmund W. Leifson. 202 pp. $2.50. Reinhold Publishing Corp. New York. 1945.

This little volume can be recommended to those who wish to understand something of the background and principles of one of the foremost scientific achievements of history. This is true for those with technical training as well as for those with none. The former will find many of the early sections on the fundamental ideas of physics and chemistry, the source and forms of energy, and the how and why of explosions elementary, but they will look long before they find another nontechnical presentation as clear, readable, and concise as this one.

The first thirty sections (there are no chapters, although the authors' orderly arrangement would have permitted this more formal grouping) give us some recent and ancient historical background and the fundamentals mentioned above. The next twenty-odd introduce the nucleus, its particles and forces; radioactivity, natural and induced; the neutron; isotopes; the instruments of nuclear physics; and uranium, its isotopes and reactions with neutrons.

These are followed by a summary, useful in orienting the reader, and a statement, excellent though brief, of the staggering problem faced in translating the meager data and limited knowledge available in 1940 into a full-scale productive process.

The third portion is devoted to a lucid account of the facts, problems and solutions leading to the successful production of U–235, plutonium, and the atomic bomb. This follows Professor Smyth's report closely, omission and subordination of details having contributed materially to logical presentation and clarity with no sacrifice in accuracy.

The closing sections discuss briefly the

future military and peacetime possibilities of atomic energy and its social implications.

Atomic Energy in War and Peace may have been a "quickie" in preparation but will repay careful reading.

MERRILL E. JEFFERSON
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Electrons in Action. James Stokley. 320 pp. Illus. $3.00. Whittlesey House. New York. 1946.

HERE is a nontechnical book on one of the more technical fields of physics, which turned out surprisingly well. With "electronic" becoming almost a catchword, this book is recommended for those who wish to learn something of the history, present status, and future possibilities of electronics.

Following a brief introductory chapter, three are used to introduce the electron, the vacuum tube, and the fundamental functions of these tubes in both their simplest forms and the more advanced forms, the Klystron and magnetron.

Subsequent chapters deal with the now commonplace radio and its more glamorous offspring, television (I found the historical material of particular interest); the electrons of the upper atmosphere and their part in radio transmission; fluorescent light; sound recording and reproduction.

Chapters ten and eleven should be of considerable interest to most readers since they present, in considerable detail, many interesting applications of electronics which, though important, have not received the public notice accorded to X-rays; the electron microscope; and medical applications such as induction heating and the measurement of body potentials, subjects discussed in the next chapters.

Next follows an excellent account of particles and their acceleration and use. The closing chapters deal with atomic energy, the author quoting freely from the Smyth report. An appendix presents the latest information available on radar and related ranging and navigation systems.

The book is well printed and contains fifty-four figures and thirty-two interesting plates.

MERRILL E. JEFFERSON
NEW ORLEANS, LA.

You and the Universe. John J. O'Neill. 319 pp. $3.50. Ives Washburn, Inc. New York. 1946.

A CAPABLE journalist has undertaken in this volume to survey the advances of all fields of science from the Harvard Conference of Arts and Sciences in 1936 to the present and to interpret "the advanced erudition of the scientists in the terms of everyday speech"—a highly commendable end attained to an unusual degree in this collection of the author's science writings for the press.

The varied nature of the subject and its popular treatment make a detailed review impractical. Specialists in the several fields may question the selection of some of the featured stories as those of "timely interest and lasting value"—to quote the publisher—but the reader will enjoy an unusually high percentage of them and recognize many as news of the day, often wishing for the missing date line and illustrations. Book One: *Of Man* takes him from the gigantism of early humans and the possible implication of Milne's *tau* time (Anthropology), to Rhine's prerecognition and psychokinetics (Psychology) by way of Archaeology (item: poetry of the fourth millenium B.C.), Zoology (item: "living fossils"), Biology (item: environment vs. heredity), Physiology (item: light and health), and Medicine (item: curing with cold). Book Two: *Of the Universe* presents highlights from Climatology (item: how hurricanes are born), Mathematics (item: Einstein and space), Physics (item: atomic energy), Chemistry (item:

mineral wealth in the seas), and Astronomy (item: clouds in space).

O'Neill has an unusual facility in expressing technical subjects in a readable manner (the soporific character of statistics on population and longevity and the astronomical figures of nuclear and celestial problems is surprisingly suppressed), although at times the sustained daily-press pace is trying.

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TOM BARBOUR'S SHEARS

A Naturalist's Scrapbook. Thomas Barbour. 218 pp. Illus. $3.00. Harvard University Press. 1946.

As NEARLY everyone knows, Dr. Thomas Barbour was the late Director of the Museum of Comparative Zoology at Harvard College, which was founded by Louis Agassiz. He died on January 8, 1946, in his sixty-second year. Judged by the gusto that exudes from his pages, Tom Barbour must have enjoyed very much indeed the popular writing that he engaged in during the last four or five years of his life. But actually he *was* a man of great gusto, and who would want an autobiographer to escape from himself? Whatever his writing lacks by way of polish and literary finesse it makes up for in the forthrightness and facile expression of a *bon vivant.* And then there was also in T. B. a goodly portion of the sublime ego, and this too was inescapable when he came to write and reminisce. But you would not expect a man who stood six feet five, mentally and physically, to shrink to a Lilliputian the moment he took pen in hand.

The present volume is just what its title indicates—a scrapbook. It is not a particularly important book when considered by itself, but it does fill a few gaps in T. B.'s recorded life and work and should be read along with his *Naturalist at Large, That Vanishing Eden,* and *Naturalist in Cuba.* For the most part it is concerned with matters of interest to other museum curators, anecdotes of museum life, some of the philosophy of Barbour's own museum administration and scientific work, and odds and ends of his thinking and writing. Included, too, are thumbnail portraits of some of his friends and associates at M. C. Z.—notably, Alexander Agassiz, Samuel Garman, Outram Bangs, and Walter Faxon. The "scrapbook" contains also considerable historical material relating to the Museum of Comparative Zoology, the Boston Society of Natural History, and the Peabody Museum in Salem, Mass. Finally come a reminiscent chapter called "The Spice Islands Forty Years Ago," describing the Barbours' trip to these islands about 1905; a similar travelogue on Bali and Lombok; and various and sundry paragraphs on the subject of zoogeography, on which Barbour was a recognized authority.

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COMMENTS AND CRITICISMS

Scientific Beachcombing

In the October 1945 SM, Mr. O. F. Evans gave his explanation of the formation of what have been termed "beach cusps." A close reading of this article leaves the student with the impression that the explanation is not complete and further that "beach grooves" are what are really made and the "cusps" are merely incidental small headland-like processes left after the grooves have been eroded.

In the December 1945 SM, Mr. Hiram W. Hixon says that Mr. Evans expresses his opinion, but does not give the cause of shore scalloping. Mr. Hixon then gives his theory, namely that water poured from a wide-mouthed graduate is drawn into reduced cross section by surface tension. He apparently overlooks the facts that increased speed due to gravity reduces the size of the stream, that a wave slides down a beach as wide as it dashed up, and that if his theory were correct, beach scalloping would be normal instead of a rather rare occurrence.

In the same issue Mr. Bassett Jones advances a theory that the size of the groove is dependent on the average size of the sand or gravel particles of the beach, the distance between mean high and mean low tides, and the average size of the breakers. His first and second points seem obscure, and it is a pity that he did not elaborate upon them.

Both of these contributors understood that the grooves are formed and that the cusps are incidental.

In the January 1946 SM, I advanced a purely speculative hypothesis which I termed probably "inadequate." This was to the effect that when two series of waves travel in oblique directions heavier nodes are formed where the crests cross one another. These nodes follow one another in straight columns, strike the beach at the same points repeatedly, and erode the grooves at those points.

In the March SM, Mr. Evans returns with a comment on my hypothesis. He cites an article by Mr. Branner thus: "A little over twenty-five years ago . . . in . . . 1900." He goes on to state that Mr. Branner "suggested the same hypothesis for the formation of beach cusps that Mr. Grant proposes."

I have studied Mr. Branner's hypothesis and find that it resembles mine only in that it makes use of wave series which cross one another. Mr. Branner deals with waves that approach the shore in concentric arcs, not in straight lines. He believes that a cusp is *built up at the point where the node strikes the beach.* My hypothesis is exactly the opposite; namely, that it is the node which erodes the groove. If Mr. Branner's theory were correct, beach cusps would appear as a series of mounds whereas in reality they remain as uneroded parts of the original beach level. Apparently Mr. Evans did not read either of the short articles by Mr. Branner or me carefully.—CHAPMAN GRANT.

Causation, Chance, Determinism, and Freedom in Nature

Dr. Paul Crissman states that the chance of drawing the perfect spade hand is the thirteenth power of one-fourth (December 1945 SM, p. 460). According to my calculations, the chance is equal to $52!/13!39!$, which is less than one thousandth as great, according to my rough estimation.

In the next paragraph he states that, in tossing a penny, the number of heads may be expected to approach the value of one-half of the number of throws. This does not follow, since the penny is not symmetrical, and the divergence will be found to increase without limit. This can be easily seen by noting that heads exceed tails in each thousand throws. The discrepancy can be eliminated by counting heads for the first thousand throws, tails for the second, and so on alternately.—OWENS HAND BROWNE.

The Faith of Reverent Science

In THE SCIENTIFIC MONTHLY of May 1934 you published an article "The Faith of Reverent Science" that impressed be greatly, stating so many things that I had thought out for myself. I think this deserves a wider reading. Would it not be possible to reprint it by itself or in a later issue of your periodical?—CARL P. NACHOD.

The above-mentioned address by the late William Morris Davis, of Harvard, was published on pages 395–421 of the May 1934 SM. It seems undesirable to reprint in the SM articles that have appeared in it. I am glad, however, to join Mr. Nachod in calling the attention of our more recent readers to this thoughtful essay. Only articles published elsewhere will be reprinted in the SM, and only a few will be so honored.—ED.

How Moses Crossed the Red Sea

The Biblical account of how Moses and his tribe got safely across the Red Sea, and how all their pursuing would-be captors were drowned in it, has been interpreted in different ways. Many believe it to be an account of things that miraculously did happen. With these one must either agree or disagree—there is no room for argument. Many others hold, on the contrary, that nothing of the sort described ever occurred—that the whole story is just a fancy garland for the head of a traditional hero or, perhaps, a clever bit of fiction on the part of an early ruler to awe his credulous people and thus obtain from them ready obedience to his edicts. With those who hold either of these beliefs, as with the fundamentalist, there is no room for discussion, except to inquire how this account, harmless brag or deliberate deceit, evolved first into folklore and then into an accepted belief so firmly fixed that none thought to doubt it.

Still others hold that Moses and his people actually did cross over safely and that their pursuers were drowned in the sea, but claim that everything came about as the result of natural causes. It has been surmised that a great north wind blew the water south from the upper end of the sea and that it was here and then that Moses crossed. But no one could march against a wind so strong as this would have to be, nor does the record mention a north wind, but one from the east. Besides no wind can blow both ways at once—to the right and to the left—in such manner as to clear out a broad passage, with water on either side, as described in Exodus.

Another surmise is that the water was pushed out of the upper end of the sea by a great increase there of the pressure of the air, and pulled back in time to catch the Egyptians by an equally great decrease of pressure. This looks, at first, to be a good guess, but it has a serious defect—no such changes of the pressure of the atmosphere as would be necessary to produce such effects as these are known ever to occur.

Still another suggestion is that the Egyptians were drowned by a tidal wave caused, presumably, by an earthquake. This might account for the disaster to the Egyptians but it would not make a way for the Israelites to cross over on dry land. Even the ebb that often precedes a tidal wave is of too short duration for the crossing of a multitde. Indeed all attempts to find an adequate physical cause for the alleged ebb and flow of the Red Sea appear to be hopelessly futile.

But there is another possible approach to this problem, one that accepts the honesty of the account and yet avoids appealing to the miraculous. This is, that Moses fled from Egypt by a route, perhaps little traveled, if at all, just beyond the northern end of the Red Sea, at a time when anyone who did not know definitely to the contrary would be sure that what he saw was, indeed, the Sea. However, on approaching it its waters would recede, and, on going considerably farther, part in the middle, with water to the right, water to the left, receding water in front and closing water behind, and dry sand underfoot though at the bottom of the sea only a few minutes before—a mirage all around. On getting across onto slightly higher land he could look back and see whatsoever might be pursuing him plunge into the sea he himself had just crossed and presently disappear beneath its surface—drowned, of course. Whereupon he would go on rejoicing.

Presumably, too, the Egyptians, being intent only on recapturing their slaves, gave over the pursuit as soon as, on nearing the mirage, they saw them (the Israelites) sink beneath the surface of the sea—hopelessly lost.

Just such a mirage, indeed, as that here supposed can even hide armies from each other, as one did during the battle of April 11, 1917, between the British and the Turks, in Mesopotamia. "The fighting had to be temporarily suspended," General Maud, the British Commander, reported, "owing to a mirage."

Anyhow, whether Moses did, or did not, go through a mirage, the account of his crossing the Red Sea is an excellent description of what he would have seen if he had done so.—W. J. Humphreys.

Tax Capitalization

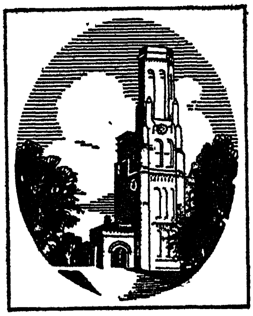
The empirical approach to economic theory, presented by Dr. Wehrwein, of the State Department, in his discussion of tax capitalization (May SM, pp. 447–449), is mischievously plausible as is all empirical argument in the social sciences.

In the hope of counteracting the mischief of his conclusion that "economic theory should not be made to be more logical or consistent than human beings or their economic activities themselves are," let us quote from a leader in economic theory, Prof. J. B. Clark, writing about "Capital and Its Earnings," over fifty years ago:

"Economic theory, whether recgonized or not, is a mainspring of political action, and a faulty theory, widely taught, is sure to bear fruit in bad action."

Must we forever remain as illogical and inconsistent as civilized society is today?—Alden A. Potter.

THE BROWNSTONE TOWER



I have just returned to my desk from the top of Washington Monument where I gazed again on this beautiful city. How long will it remain a center of civilization? Will it grow to maturity or is it doomed shortly to become another Berlin or Warsaw? The release of atomic energy for destruction insistently raises these questions. The SM, "broadly interpreting to the thoughtful public the progress of science and its relation to the problems confronting civilization," would fail in its purpose if we should avoid this supreme problem. We do not intend to neglect it, yet we have hesitated to add to the flood of articles that have appeared on atomic energy and its control until we could present an outstanding essay worthy of our readers' attention. The leading article in this issue is the best that we have read since the fateful sixth of August, 1945.

Most intelligent, mature people have a long-established conviction that war can be prevented or suppressed only by world government. Many years ago H. G. Wells preached that doctrine and must have converted many of his readers. But the problem once nebulous has now become concrete owing to current events and to the efforts of scientists and students of government like Professor Schuman. His present essay dissects the problem with admirable clarity. Here is no wishful thinking but a lucid analysis of the present situation based realistically on what is politically possible. He urges continuous effort to promote concord among the Great Powers so that world control of atomic energy can be established within the UN. If that can be brought about as recommended in the Lilienthal-Acheson Report, the first and most important step toward a federated world government by law will have been accomplished. Perhaps the first small beginning was made when the Senate at last passed the McMahon Bill. If it becomes law, we shall then be in a position to negotiate for world control of the greatest menace to civilization that has ever arisen.

Professor Schuman, as a student of the history of government, is compelled to close his essay with a note of pessimism, which we think is fully justified by present events. When even those who are intellectually convinced of the necessity for a federal government of the world find it difficult to escape from habitual thinking in terms of nationalism and when the mass of people everywhere are not encouraged by their leaders to depart from traditional patriotism, there seems little hope that a change of heart will come in time to prevent the tragedy now in store for civilization. And yet everyone who understands the peril confronting the world must try to avert it by whatever means are open to him.

As Professor Keller says in his present essay on fear, "What men want is to eat, drink, and be merry. In dire peril, too imminent to be ignored, they have risen to the lift of a great Leader; but as soon as they cease to fear, they are ready to slump back into the comfort of 'normalcy' . . ." Our present danger is that we do not really fear the unseen atomic bomb. Like the people described by R.L.S., we are living on the slope of an active volcano. "There are serenades and suppers and much gallantry among the myrtles overhead; and meanwhile the foundation shudders underfoot, the bowels of the mountain growl, and at any moment living ruin may leap sky-high into the moonlight, and tumble man and his merry-making in the dust."

On this bright June day the Monument looks down upon the fairest works of man and nature. Will nature alone survive?

What a splendid world we could have if man would contend with nature only for his

own benefit! One of finest stories of man's fight against the malevolence of nature that we have ever published appears in this issue. Let us hope that men like Marston Bates can long continue their beneficent investigations.

The editor and his associates are always considering ways and means of improving the SM within the limits set by personnel and income. Those changes that seem desirable and feasible are made in the first issue of a new volume. Thus the present issue, beginning the sixty-third volume, is covered by coated paper on which the cover design has been somewhat modified. The primary purpose of this change is to improve the appearance of advertisements on the cover pages and to pave the way for the use of color on these pages. When and if Mr. Christensen contracts for a colored advertisement on the back cover, the black strip across the top and bottom of the front cover page will be changed to a suitable color, resulting, we hope, in a still more attractive appearance all around.

Color printing is so expensive that it is not a step to be taken lightly in the SM. We have been considering it for several years and are now authorized by the majority of our advisers to experiment with it in order to add to our experience and to find out whether our readers think it is worth while. Therefore we are beginning in a very modest way with the help of the Bausch and Lomb Optical Co. In their magazine called *The Educational Focus* (17(2): 11–18. 1946) the Company has published an article by J. V. Butterfield on "Color Photomicrography" illustrated by two pairs of colored photographs of certain crystals. The Company kindly lent us the plates of these colored illustrations and gave us information and advice about their use. They permitted us to reprint the article by Butterfield and gave us black-and-white prints of the crystals, which were not used in the original publication. Therefore we have published Butterfield's article in this issue with a colored insert so that the black-and-white photomicrographs can be compared with their colored counterparts. This was the least expensive way to make our first experiment in color, which would not have been undertaken without the generous support of Bausch and Lomb. Unless our readers disapprove, we will use color in principal articles from time to time when it adds scientific as well as esthetic value to illustrations and when color plates are provided or paid for by the contributor. It is our hope, of course, that we may be able someday to publish in the SM without cost to the contributor all suitable colored illustrations submitted with acceptable manuscripts.

Heretofore the items published under "Comments and Criticisms" have been given brief titles by the editor unless the writer provided a suitable title. The editor's titles sometimes reflected editorial reaction to the letters and sometimes were intended to be noncommittal. Titles of the latter character were often taken from some phrase in the letter to be titled. This practice led to an embarrassing incident for which the editor desires to make public apology. Comments on Major Chapman Grant's biological explanation of the origin of the Carolina "bays" (SM, December 1945) were entitled "On Grant's Fish Story," suggested by one of the letters. Major Grant was offended because it naturally seemed to him that the editor was indulging in ridicule. On the contrary, the editor feels that Major Grant's hypothesis is entitled to serious and respectful consideration, which it did not receive from those who commented on it. The same applies to his hypothesis on the formation of "beach cusps" (SM, January 1946), a comment on which was entitled "Armchair Geology." To prevent such misunderstandings in the future each letter commenting on a published article will bear the complete or partial title of the article eliciting the comment. This change in policy should help also to sooth one of our readers who feels that "Comments and Criticisms" is so lacking in dignity and scientific value that it should be eliminated from the SM.

F. L. Campbell

THE SCIENTIFIC MONTHLY

AUGUST 1946

SCIENCE AND INCENTIVES IN RUSSIA

By IRVING LANGMUIR

ON MAY 19, 1945, less than two weeks after the end of the war in Europe, I received from the Embassy of the U.S.S.R. in Washington a short letter inviting me "to participate in the festivities to be held in Moscow and Leningrad from June 15 to June 28 in celebration of the 220th anniversary of the Academy of Sciences of the U.S.S.R." In a postscript it was stated that "travel expenses and expenses of a sojourn in the U.S.S.R. will be paid by the Academy of Sciences of the U.S.S.R." No other information, giving more particulars as to the nature of the meetings that were planned, was received from the Embassy.

I called up the State Department regarding the possibility of getting a passport and priority for transportation. They had no official knowledge of these invitations, but a few others who had been invited had telephoned as I had. It was doubtful that more than two delegates from America could be sent, but I was asked to call again the next day for more information. The following day I was told that passports and priorities would be issued for all those invited. The time was short, and it would be necessary to go by airplane, but because of the heavy Army traffic it was not possible to decide upon the route until two days before departure. The possible routes were via England or by way of Africa and Teheran, via Newfoundland, Bermuda, or South America. It was essential to make application for passport and transportation immediately, so forms were mailed at once from Washington. When they arrived I found difficulty in filling them out, for the passport application required me to state the date of departure, the route, and all stopping places; the application for transportation required me to give the number of my passport.

I filled out everything I could and wrote a letter saying that the State Department had informed me that the particular route could not be decided until a few days before departure. I needed to be in Moscow on June 14 and suggested that the State Department fill in the blank spaces. (When I returned from my trip to Russia early in July, I found that several days after my arrival in Moscow the State Department had written me that my passport and application for transportation had been rejected because the application forms had not been completely filled out.)

I accepted the Soviet invitation by telephone and letter and was informed that transportation would have to be arranged for by the United States government. On the evening of Monday, June 4, I suddenly received a telegram indicating that I must be in New York by

Tuesday noon to get proper visas for my passport, which was to be brought by special messenger from Washington. A Soviet plane would start from San Francisco, picking up delegates on the way, and would leave New York early Wednesday morning, taking the whole delegation to Moscow via Alaska and Siberia. The baggage was "limited to 25 to 30 pounds." We found later that this should have been 30 kilograms, or about 66 pounds.

Two members of the party arrived in New York on the Soviet plane Wednesday afternoon, but because of minor difficulties this plane was not ready to leave until Thursday evening. In the meantime, we found that the Soviets would not be allowed to operate passenger planes in the United States, and the only plane available was a cargo plane with insufficient seats for the whole party. It was, therefore, finally arranged by the State Department and President Truman that the party would be taken by the Air Transport Command in a C–54 plane to Teheran via Newfoundland, the Azores, Casablanca, and Cairo. A Russian plane would meet us at Teheran, and we would return from Moscow in a Russian plane to Fairbanks and thence to the United States by an Army plane. The final party as it left America consisted of James W. Alexander, Merrill Bernard, Detlev W. Bronk, James W. Church, Henry Field, Jacob Heiman, Charles E. Kellogg, I. M. Kolthoff, Irving Langmuir, Duncan MacInnes, James W. McBain, A. P. Nadai, A. U. Pope, Harlow Shapley, Edwin S. Smith, and M. S. Vallarta. The party was joined in Moscow by T. von Karman. There were thus 5 chemists, 2 archeologists, 2 meteorologists, and 1 each from the fields of mathematics, biology, medicine, astronomy, and mechanical engineering. No physicists were among the delegates, although 12 had been invited.

It is a serious reflection on the state of American public opinion and understanding of Russia that most of our friends felt we were undertaking a hazardous expedition. Many of them warned us that 16 Poles had been "invited" to Russia and that they did not come back; they wished us better luck.

We finally left New York early on the morning of June 10 and arrived in Russia at Baku on the Caspian Sea at 8 o'clock on the morning of June 14, after having spent 24 hours in Cairo. At Baku we were met by a group of local public officials and members of the newly formed Academy of Sciences of Azerbaijan. We were then at 8:30 A.M. taken to a banquet with perhaps 25 different articles of food, including two kinds of caviar, smoked sturgeon, cold and hot meats and fish, with several kinds of wine. Although during our short stay in Cairo some members of our party had acquired dysentery (which was quickly cured by sulfa drugs), we were assured that in Russia it was always safe to drink water. I saw a large carafe on the table in front of me and filled a glass, only to discover quite suddenly that it was vodka, which contains 50 percent alcohol. We always found that vodka and water were in identical carafes.

After a perfunctory baggage examination we left Baku by plane and in perfect weather flew via Stalingrad to Moscow, a distance of about 1,100 miles. Beyond Stalingrad we flew for 500 miles over an unbroken area of collective farms visible for a hundred miles on each side of our route. All the land was under intensive cultivation. It included about 10 percent forest. At frequent intervals we passed over "inhabited places," like those we heard so much about during the war. They were usually villages of perhaps 50 well-separated houses, arranged on both sides of a street or road about 200 feet wide. Each house had its

own vegetable garden of about an acre. Most of these towns had small artificial lakes or ponds. Each village was surrounded by the collective farm of many hundred acres cultivated by use of tractors. We were so much interested in these farms as seen from the air that we arranged to visit one of them during our stay in Moscow. At the same time we were also shown a State Farm.

Arriving at Moscow about 6 P.M., we were met by a large delegation of prominent Russian scientists, including P. Kapitza, A. Frumkin, and J. Frenkel, all of whom I had previously met. We were then taken to the National Hotel. One by one we gave up our passports to the hotel clerk and were assigned rooms on the second and third floors. I happened to be the last one to check in. After I had given up my passport I was motioned to a chair near the desk and there I sat for well over half an hour. No one around me spoke English. Gradually I became aware that the steady stream of people who stopped at the desk were talking about me. Although I had plenty of time to think about the remarks of my friends regarding the 16 Poles, I was more amused than worried.

A man who spoke a little English finally came to me and explained, "You are not staying here."

I replied, "But I would rather stay here with the rest of the party."

"None of them is going to stay here," he answered. So one by one the men who had unpacked their bags and made themselves at home in their comfortable quarters were notified by means of sign language that they should repack their bags and go down to the lobby.

The mystified delegates were taken with their belongings in a large bus across the street to the Moskva Hotel, which had been used exclusively by Russians. There we had excellent adjacent rooms with baths, all on the eighth floor. There was a convenient meeting place having a large table and comfortable chairs, with desks for the women who were to act as translators, provide for our transportation, etc. It was, in fact, a much better arrangement, but we were surprised that it had not been thought of until we were already installed in the National Hotel.

This and many other similar situations made us realize how few parties such as ours had traveled in Russia. Edgar Snow has recently written from Moscow that there are only 260 Americans in the whole of the Soviet Union. Everywhere we met the utmost kindness, but all those who looked after us were having a new experience, as novel for them as it was for us.

The next morning, after brief consultation with some of the others, I asked one of our interpreters how we could get some Russian money in exchange for our traveler's checks. She looked at me in astonishment and said, "What do you want Russian money for?" I said that I might want to buy a newspaper or ride in a subway or take a taxi. She assured me that all such things had been thought of and would be taken care of. There were no taxis, and we would have automobiles at our disposal to take us wherever we wanted to go; for instance, we would certainly be taken to see all the important stations of the subway as the subway is one of the sights of Moscow; as for newspapers, we would receive the *Moscow News* in English before breakfast. I then suggested that I might like to buy a present to take home to my wife. She remarked, "Oh, I don't think you will want to do that"—and, in fact, I didn't. I then wondered whether there was a real desire that we shouldn't have Russian money. When I suggested this, my interpreter was horrified at such an idea and said, "No, of course not." She

clearly was merely surprised at the thought that we should want money when all our hotel bills and other necessary expenses were being taken care of. This was one of many experiences that demonstrated to me the relatively small part that money plays in the lives of the Russians.

Still wishing to obtain Russian money, however, we found it involved many difficulties that had not been foreseen. There was only one bank in Moscow that could deal in foreign exchange, and there, to get money in return for traveler's checks, it would certainly be necessary for us to have our passports and to have somebody who could identify us. The trouble was that the passports had been given up at the hotel and would not be returned for five days. I finally acted as agent for the whole party, arranged to get my passport from the safe where it had been kept, and with a young man from Intourist went to the bank and got $250.00 in rubles for the whole party. During the rest of our stay we all tried to discover ways in which we could spend the money. We had been given rubles at the official rate of exchange of 5 rubles to the dollar. (The American Embassy and its staff gets 12 rubles to the dollar.) A few days later, during an intermission at the opera, we went to a restaurant where refreshments were being served. We found that one piece of French pastry cost $8.00, and a cup of tea or glass of beer, $3.50. Chocolate bars sold at $85.00 a pound; a plate of ice cream, $6.00. Yet the place was crowded, and people were waiting in line to buy ice cream.

On the streets healthy looking peasant children of six dressed in heavy, padded winter clothing, presumably because they did not have any summer clothing, were buying very small amounts of ice cream for $2.00.

My bewilderment at this kind of economic system led me to ask many questions. I found that the people's purchasing power is determined by a farreaching rationing system which applies to food, clothing, cigarettes, housing, railroad transportation, and even opera tickets. Rationed goods are sold only at certain stores at low fixed prices which are about the same as those before the war. At the rate of 5 rubles to the dollar these prices are not greatly different from those in the United States. The balance of supply and demand is not regulated by prices but by the number of ration points that are issued.

There are also a large number of other government-operated stores called commercial stores, which in Moscow all carry the name *Gastronom.* In these stores no ration points are needed, but the prices are fantastically high, ranging from 10 to 100 times as much as those at stores selling rationed goods. Every worker or employee receives much more money than is necessary to buy his allotted amount of rationed goods. The surplus can be used only for goods at extremely high prices. It is no wonder, then, that money is regarded as not having great value.

In the commercial stores the balance of supply and demand is adjusted by flexible prices rather than by wages. The high prices at these stores reflect wartime scarcities. Already, before June 1945, there had been two cuts, averaging about 25 percent each, in the prices, and I understand that since then there have been further substantial reductions. It is interesting that books and other goods which are considered to be of cultural value sell at prices about like those in England and America.

There are also great numbers of free markets where anyone can buy and sell or exchange articles without government restrictions on prices. Competition naturally holds these prices somewhat lower

than those at the commercial stores. There were 49 such markets in Moscow alone. Produce raised by the farmers of the collective farms on their private one-acre lots is sold at high prices in these markets. At the stations where we stopped on our train trip from Moscow to Leningrad we found that farmers were selling milk at $4.00 a glass, with plenty of demand for their product. It is not surprising, therefore, that peasant children can afford to pay $2.00 for ice cream.

The rationing system serves as a basis for the remarkable system of incentives that dominates Russian life. This system was started in 1931 when the Soviet government adopted the policy that men should "serve according to their abilities and be paid according to their services." Piecework rates are universal throughout industry, but when definite quotas and superquotas are exceeded, the piecework rate often increases as much as two- or threefold for all output exceeding the quotas.

The Russians justify this by explaining the great reductions in "overhead" that are possible when the output of a man increases. With the increased pay go corresponding increases in the allotment of rationed goods.

The spread in the rates of pay in Russia is even greater than in the United States. For example, if a man works up into a good position, he may receive as much as five times more food ration points. Just imagine the protests that would have arisen in America during the war if a college professor or the president of a company had received more red ration points than a factory worker. In Russia, however, since they have adopted a powerful incentive system and the pay for services rendered consists primarily of ration points, it is logical that the allotment of food and other rationed goods should vary in quantity with the work done or the position held. In many cases the food allotted to an individual is far more than can be consumed by him. That means he can entertain his friends or can even sell the surplus on the free market. For example, people who do not smoke may buy their allotment of cigarettes at low prices and then sell them in the streets for one ruble (20 cents) each.

There are many other provisions for increasing incentives. Special prizes are offered those factory workers who have the greatest output. The women who acted as translators for us during our stay in Moscow received not only their usual salary but got as a bonus coupons which entitled them to buy two pairs of silk stockings at low prices.

For scientists there is another kind of incentive. Just before the anniversary meeting of the Academy of Sciences 13 Russian scientists were awarded the highest of all honors, "Hero of Socialist Labor"; 196 received the Order of Lenin, which only a few months ago was awarded to Molotov. A total of 1,400 awards was made. An article appearing in the *Moscow News* in June 1945, entitled "Science Serves the People," contained the statements:

> Never before has the scientist been accorded such attention by the state and such esteem by society as in the Soviet Union. . . . The state provides the maximum amenities for life and facilities for work to the scientist and assures a comfortable life to his family after his death.

It is continually being pointed out by the Russians that their system of incentives is rapidly increasing the efficiency of production and is thus one of the main factors that will help to make Russia great and will make possible a high standard of living. When I expressed surprise that so much emphasis should be placed on incentives the reply was usually, "But I thought that it was a particular characteristic of your capi-

talist system in America that great rewards were given to those who became leaders or acquired important positions in industry or business." I had to explain that in America that was originally one of the effects of the capitalist system, but that in recent years our government had regulated and controlled all incentive payments by taxes and by special laws so as to stifle incentive to a large degree.

THE meetings of the Academy were, as was indicated by the wording of the invitation, "festivities" commemorating the anniversary. Detailed scientific papers were not presented. The plenary meetings, which were held in large opera houses with about 3,000 people present, were devoted to a few general papers on the history of science in Russia and in other countries and on selected subjects of wide general interest.

Most of the meetings included entertainments such as symphony orchestras, ballets, or operas. All these performances were of extraordinarily high quality. They demonstrated very clearly the great importance that the Russian government and people attach to cultural subjects. Later, as we came back across Siberia, we stopped at Novosibirsk, a town which had grown from 80,000 to 900,000 during the war. During this growth, even at a time when the housing facilities were very inadequate, the government built an opera house seating about 3,000 people and arranged for operas, concerts, and other entertainment of the same quality as at Moscow.

The anniversary celebrations included three banquets for 1,100 guests, with all the lavishness that was characteristic of prewar Russia. The last of these banquets was held at the Kremlin in Moscow with Stalin in attendance and Molotov as toastmaster. Before leaving America I had been repeatedly warned about the excessive drinking at such banquets. In Moscow, only a few hours before the banquet at the Kremlin, I was told by a man in the United States Embassy that this banquet would be "the real thing," and that for the toasts to Stalin of which there might be thirty, it was essential to drink vodka only; a full glass must be emptied for each; to do otherwise was considered an insult. Actually, I found less drinking than is usual in America. At the three banquets I saw only one man who reached the slightly-incoherent stage. About half the Russians responded to a toast to Stalin merely by clapping; the others, after the clapping, lifted their glasses and took a sip or two of wine, vodka, or orangeade. So far as I could judge from observations of Russian scientists, the drinking habits and capacities of the Russians are greatly exaggerated.

The Academy of Sciences has 142 regular members and 200 corresponding members. Membership is determined by secret ballot by members only. Corresponding members have "a voice but no vote." All members receive salaries from the government. The Academy has 8 sections, which include not only the natural sciences, biology and medicine, but also social sciences such as economics and law, history and philosophy, language and literature.

Within the Academy are 78 Institutes employing 15,000 men and women. The planning of the work of the Institutes is done by the members of the Academy, and they are responsible for its success. In Russia there are about 790 universities, with over 600,000 students, but these are not connected in any direct way with the Academy of Sciences.

More than 100 foreign scientists attended the anniversary meetings as guests. Most of our time during the 18 days in Moscow and Leningrad was spent in informal conferences in any of the

Institutes that we wished to visit. I naturally chose those in the fields of chemistry and physics. The Russian scientists talked freely about their work and showed me all through their laboratories, but they never sought information about work that we had been doing during the war nor about industrial developments in America. I was nevertheless much impressed by the friendliness of all these men and their wholehearted devotion to science. They were all clearly working on problems that had been planned by scientists who were free from undue political control. In fact, they had been able to carry on during the war scientific work of a kind that would have been impossible in the United States. A great deal of the work was of long-range character, which was often planned to lay sound foundations for postwar industrial developments. They had been able to defer men from active military service for such work, whereas in America it had often been impossible to get men deferred even for essential war work.

The progress in science in Russia during the war was greater than we had expected. In some fields the Russians are leading the world. The advance in scientific knowledge in agriculture, especially in soil chemistry, has been remarkable. The geological work done in Soviet Asia alone is estimated to have exceeded that done by the British government in India by perhaps fifty times.

Kapitza's laboratory in Moscow, which is superbly equipped, is devoted to the study of extremely low temperatures and to the large-scale liquefaction of gases. Several scientific discoveries of great importance have been made during the war in connection with the extraordinary properties of liquid helium, which behaves as if it consisted of two mutually interpenetrating liquids that have separate properties and can move independently of one another. This work has no apparent industrial applications.

Kapitza told me in considerable detail of a huge project to use nearly pure oxygen instead of air in the operation of blast furnaces and Bessemer converters in the manufacture of steel. From tests already made he concludes that the output of a blast furnace of a given size can be increased about fivefold by the use of oxygen, and the duration of a "blow" in the Bessemer process is cut to one-tenth. He estimates that the over-all cost of steel production will be reduced 30 percent. A $100,000,000 pilot plant to operate one or more blast furnaces continuously was nearly complete, and plans were being considered for the use of oxygen in the whole Soviet steel industry, which would involve capital expenditures of about $2,000,000,000.

Very great progress has also been made in other fields of science. Some excellent work has been done on synthetic rubber and on some plastics that are particularly good electric insulators.

On the whole, I believe that Russian scientists, except in a few fields, have not progressed as far as those of England and America. They are, however, embarking on a scientific program larger than is contemplated by any other government, and with their pioneering spirit, enthusiasm, and universal appreciation of the value of science, I believe that they may well forge ahead at a faster rate than we shall.

During the years 1934 to 1941 the Soviet government realized fully the dangers of German aggression. Instead of adopting a policy of appeasement like that of other governments they started a tremendous program of military preparation which enabled them ultimately (with only 8 percent of equipment supplied through lend-lease) to drive back the German armies from Stalingrad to Berlin. This was done by sacrificing the

higher living standards that would otherwise have been possible.

I lived in Germany as a student from 1903 to 1906 and made many subsequent visits to that country. I was always disturbed by the aggressive, militaristic spirit of the Germans, by their ideas of racial superiority, and especially by their belief that moral scruples should have no place in international relationships. One prominent German told me in 1921 that he considered the United States government criminally negligent in not fortifying the Canadian border.

In Russia there is an entirely different spirit. All the people that I met have a real desire for security against aggression and for world peace. Several of them in addresses at a session restricted to Academy members and their foreign guests emphasized that science had always been international in character—all nations had profited by the free interchange of knowledge; they hoped that similar cooperation in other fields would be possible.

Typical of many of the expressions of good will was the following toast proposed by our Soviet host at Yakutsk in Siberia as we were stopping en route from Moscow to Fairbanks:

To the Soviet Academy of Sciences,
To our scientist guests, and
To the Soviet Union,
In behalf of eternal peace.

INSTITUTIONAL AND PERSONAL EXHIBITS

The Science Exhibition, Boston Meeting, December 26–31, 1946

The Science Exhibition at the Boston Meeting will consist of commercial and nonprofit exhibits. This notice concerns the latter only; that is, those exhibits furnished by institutions or individual investigators to portray advances in various fields of science and to demonstrate new techniques and apparatus for teaching or research. The Committee on Exhibits, wishing to encourage the presentation of nonprofit exhibits, has instructed the Director of the Exhibition to make the following announcement:

Both nonprofit and commercial exhibits will be housed in the First Corps Cadet Armory opposite the Hotel Statler, which will be the headquarters of the Boston Meeting. With possible exceptions to be made at the discretion of the Committee, the space to be provided for each exhibitor will be ten feet wide. All booths will be six feet deep and will have a ten-inch shelf all around. Illustrative materials can be tacked or hung on the plywood backs of the booths. No charge will be made for the use of these booths. General illumination, necessary electrical outlets, two chairs, uniform name signs, and general service will be furnished without cost to the exhibitors. They will pay only for preparation, transportation, and installation of their exhibits and for any special construction or extra furniture that they may require for their booths. A decorating firm will provide such special materials and services at regular rates.

Those who are interested in exhibiting at the Boston Meeting should immediately request application forms from:

Theo. J. Christensen
Director of the Science Exhibition
A.A.A.S.
Massachusetts and Nebraska Avenues
Washington 16, D. C.

The closing date for receipt of applications will be September 15, 1946. Applications will be considered by the Committee as soon as possible after that date. Preference will be given to proposals that show originality in subject and method of presentation, and to exhibits that will be attended by a demonstrator. Applicants will be notified promptly of the action of the Committee.

THE RESPONSIBILITIES OF HEALTH-PHYSICS

By KARL Z. MORGAN

MONSANTO CHEMICAL COMPANY, KNOXVILLE, TENNESSEE

WITH each passing year, life on our planet becomes more intricate; man is made the guardian of greater responsibilities, and with a better understanding of the universe he is acquiring an almost incredible power for good or for evil. Man is faced with many new problems introduced by developments in the physical sciences. Sometimes in retrospect it appears that man somehow finds the right answers, and there is danger of our being lulled into the belief that in the nick of time man will always choose the proper course to nourish and preserve those things we cherish. Our forefathers had their problems of individual preservation but they were not entrusted with instruments capable of such mass destruction as we are today. We have learned to enjoy the excitement of delving into the unknown and of seeing unraveled before our eyes the mysteries of creation. Life must have seemed just a bit monotonous to Professor Michelson at the University of Chicago in 1894 when he made the statement that the underlying principles of the physical sciences had been firmly established and that future truths were to be looked for in the sixth place of decimals. The following year, on November 8, 1895, W. C. Roentgen discovered the penetrating radiation which was called X ray and thereby introduced to man the first entity of the atomic age.

Half a century later, on December 2, 1942, in the Metallurgical Laboratory at this same University of Chicago, the atomic age was really born into the world. Here for the first time man constructed and operated a self-maintained nuclear chain reaction. This was a great day for the physicists. For ages man had sought the secret of the sun's energy and a practical means of converting one element into the other. Here was a pile of uranium and graphite undergoing a controlled thermal chain reaction and giving off energy in a manner similar to the high-temperature light element chain reaction on the sun, and in the process relatively large amounts of various elements were being produced as many billions of uranium atoms fissioned each second.

At the very beginning of the Metallurgical Project[1] at the University of Chicago it was realized that unprecedented health problems would be encountered. Some of the scientists had considerable apprehension and doubt as to whether such operations as were proposed could be undertaken without enormous risk to the lives of persons employed on the projects. Dr. A. H. Compton, the director of the Metallurgical Project, recognized the importance of the hazards presented and employed the services of the eminent radiologist, Dr. R. S. Stone, as associate project director for health. Dr. Stone had had years of experience in radiotherapy and was one of the few men who had done neutron therapy research. Sections of Medicine, Biology, and Health-Physics were organized and placed under Dr. Stone's direction. Each of these sections

[1] The Metallurgical Project became a part of the Manhattan District in May 1943. The efforts of the various projects of the Manhattan District were coordinated by the United States Engineering District. It was its responsibility to integrate the numerous activities and to expedite all efforts toward the production of the atomic bomb. Col. S. L. Warren was made responsible for coordinating the health activities of the Manhattan District.

played an important part in maintaining the morale and in protecting the lives of the thousands of persons who were employed on the Metallurgical Project, later known as the Plutonium Project. My purpose is to describe the functions of Health-Physics, and so the other sections will not be discussed further here, other than to state that each was an efficient, effective, and vital part of the over-all program.

E. O. Wollan directed the first Health-Physics Department,[2] which actually began operation at the University of Chicago a few months before the Health Division was organized. Other Health-Physics departments were organized at Oak Ridge, Tenn., in 1943 and at Hanford Engineer Works, of Richland, Wash., in 1944. At present, J. E. Rose is head of the Health-Physics Department in Chicago, K. Z. Morgan at Oak Ridge, and H. M. Parker at Richland.

The purpose of the Health-Physics departments was to make a study of penetrating radiations and to devise physical means of preventing damaging exposures to personnel. This was an important assignment requiring the training of many men in this field; the development of a large number of new instruments; the pursuance of many problems of academic and development research; and the establishment of organizations to be responsible for radiation surveys and personnel monitoring. Past experiences with radiation hazards were not very encouraging. Penetrating radiations produced their damage so insidiously and inconspicuously at first that men had seldom been aware of receiving excessive radiation until they began to suffer from radiation burns or until years later they were victims of the great scourge cancer. In fact, a man in Chicago was attempting to find a cure for his X-ray burns only a month after Roentgen announced the discovery of X-rays. Past records indicated that thousands of people, including dial painters, physicians, dentists, physicists, technicians, manufacturers, and engineers, had been injured by X-rays and radiation from radioactive substances and that many had died from these effects. The evidence was that all these radiation injuries and deaths were unnecessary and could have been avoided. Many radiologists, radiotherapists, physicists, and others had suggested precautionary measures, but no organized effort in this direction had been made. If the suggestions by such men as S. Russ, who made certain radiation protection recommendations to the British Roentgen Society in 1915, had been considered seriously, it is possible that many of the unfortunate radiation injuries that occurred during and after World War I could have been avoided.

In the past, a few men on rare occasions had worked with one or two curies of radium at a time, but in the new operations with uranium piles and in the separation of the approximately thirty fission-produced elements from the uranium and plutonium, it was necessary to work with unheard-of numbers of curies of radioactive material as a routine procedure. Men had to be protected from radiation so intense that a fatal exposure could be received in an extremely short interval. Not only was there the problem of X-rays and gamma rays, beta particles and alpha particles, but there were neutrons of all energies, ranging from a fraction of an electron volt up to several million electron volts. When the first pile began operating in December 1942, there were many Health-Physics problems to be solved. It was realized that it was necessary not only to protect those men working on the projects but also to make certain that

[2] The word "department" will be used in place of "section" in the rest of this paper because an academic nomenclature more nearly describes the organization. Actually, most of the organizations had an industrial line organization of divisions, sections, and groups.

the areas about the plants were not contaminated and that the neighboring communities were properly protected. Unprecedented precautions had to be taken lest the unfortunate radiation experiences of World War I be multiplied manyfold in World War II.

THE first uranium-graphite pile operated in the West Stands of the University of Chicago in December 1942 had to be maintained at a very low power level because it was an experimental model. It had not been designed with facilities for dissipating large amounts of heat, and it was not felt safe to go higher because of the danger of the radiation to personnel in and around the building. After the successful operation of this experimental pile, plans were soon under way for the construction of the Clinton Laboratories pilot production plant at Oak Ridge and the large production units at Hanford.[3] One of the early responsibilities of Health-Physics was to check the plans of these new plants in order to make certain that the shielding about the pile units was adequate. The specifications of the shielding about the cells of the separations plant had to be checked meticulously; the ventilating systems from the piles, from the cells, and from the laboratory hoods had to meet very rigid requirements; and the waste solutions had to be taken care of properly in storage tanks, settling basins, and river systems. The history of the meteorological conditions at the proposed plant sites had to be studied carefully to make certain that the settling basins would not be washed away by floods and that the radioactive elements discharged into the air and river systems would be diluted sufficiently so as not to present any hazards to neighboring communities. Uranium had been handled on a small scale by a few radium plants for many years, and there was contradictory information regarding the hazards of this element. It was up to the Health-Physicists, Radiologists, and Biologists to determine the radiation hazards involved in handling hundreds of tons of uranium and to aid in determining standards, procedures, and working conditions that would guarantee the safety of workmen.

The Health-Physics departments were expanded in size and in responsibilities consistent with the development of the plutonium projects. At present there is a total of about 250 persons in Health-Physics at the three sites. This number is composed of physicists, junior physicists, chemists, engineers, meteorologists, laboratorians, and technicians. The Health-Physics activities are divided in general into three parts: (*1*) Research and Development; (*2*) Personnel Monitoring; and (*3*) Surveys.

The research and development sections of Health-Physics had to aid in making calculations on the shielding thickness necessary to protect scientists and operators from neutrons and gamma rays thousands of times as intense as any man had experienced previously. This problem was somewhat complicated in that a dense material like lead is most efficient in diminishing gamma rays, a light material like hydrogen is most efficient in stopping and slowing down fast neutrons, and elements like boron and cadmium are most effective in capturing the slow neutrons. To make matters more difficult, the slow neutrons produce penetrating gamma rays when they are captured.

In an operating pile about thirty radioactive elements are created from the fission of uranium. Some of these elements, from bromine through praseodymium, were described by G. T. Seaborg in the January 1934 issue of the *Review of Modern Physics*. All these elements are beta emitters, and most of

[3] Clinton Laboratories was first operated by the University of Chicago, and its operation was taken over by Monsanto Chemical Company in 1945. Hanford Engineering Works is operated by E. I. du Pont de Nemours & Co.

them give off gamma rays. They have half-lives ranging from a few seconds to a few years. Four transuranic elements have been announced, and these produce alpha, beta, and gamma radiations. They have half-lives ranging from a few minutes to thousands of years. As indicated in the official Smyth report, there are at least four delayed neutron emitters with a maximum half-life of about a minute. In addition to the above radioactive elements, all stable elements that are placed in the pile become radioactive from the bombardment of neutrons (and gamma rays in a few cases). Altogether this means the production of several hundred radioactive isotopes. It is the responsibility of the Health-Physicist to calculate the tolerance of each of these isotopes when the need arises and after the biologists have obtained the necessary biological information. Tolerances must be set for the amounts of the various isotopes that may be fixed in the body, and from this information calculations made of the tolerance concentrations in the air, in the water, and for surface contamination. Plutonium has presented one of the greatest potential hazards. It is an alpha emitter of many thousand years' half-life, and its tolerance amount in the body is a microscopic quantity. This has led to a tolerance concentration in the air of amounts of the same order of magnitude as for radium.

The tolerance levels of radiation are determined by the biological damage, and this is a function of the efficiency and method of energy dissipation in live tissue, the density of ionization, and the rate at which the radiation dose is administered. The tolerance value of 0.1 roentgens per day for X-ray and gamma radiation adopted by the American Advisory Committee in 1936 has been accepted by the Plutonium Projects. Fast neutrons are more harmful than gamma rays, and the tolerance value set for them is 0.025 equivalent physical roentgens (meaning 83 ergs per gram of tissue) per day, or a tolerance flux of 200 neutrons per square centimeter per second. The tolerance for thermal neutrons has been set at 1,500 neutrons per square centimeter per second. No tolerance can be set at present for the epithermal neutrons of intermediate energy, in which the energy is not sufficient to produce proton recoils and is too great to present a large probability of neutron capture. Such neutrons do lose energy to the tissue molecules, however, and their tolerance will be determined as soon as more information is obtained from physical measurements and a better method is developed for detecting and measuring epithermal neutrons. By "tolerance" we mean the amount of radiation that is considered not to produce any biological damage. Even subtolerance radiations produce certain biological changes (cosmic rays are supposed to have some biological effects), and so tolerance radiation is not what one strives to get but the maximum permissible dose. Many other calculations and measurements such as the scattering of radiation in gases and solids, bremsstrahlen calculations, measurement of radiation from extended sources, statistical calculations, and so on are made by the Research and Development Sections of Health-Physics.

The development, testing, production, and calibration of the various Health-Physics instruments that were needed on the Plutonium Projects were important assignments of the Research and Development sections. A few of the instruments they and associated instrument sections[4] developed were:

(*1*) A differential pressure chamber called Chang and Eng for measuring fast neutrons;

[4] Some of the persons in associated sections responsible for instrument development are W. P. Jesse and T. J. O'Donnell at the University of Chicago, S. G. English, C. J. Borkowski, J. R. Brand, and N. Ballou at Clinton Laboratories, and W. P. Overbeck at the Hanford Engineer Works.

(*2*) adaption of electroscopes and pocket chambers to slow neutron measurements; (*3*) development of various types of portable Geiger-Müller Counters and proportional counters for measuring alpha, beta, gamma, and neutron radiation; (*4*) development of various types of dust precipitators and filter dust collectors; (*5*) apparatus to count mechanically in 24 seconds the contamination on the hands and feet of a person; (*6*) ionization chambers and GM counters to make continuous measurements of the airborne radioactive contamination in the neighborhood of the plants; (*7*) instruments to make continuous measurements of the radioactive contamination in the settling basins and river drainage systems from the plants; (*8*) instruments to measure the alpha contamination in the hoods, on table tops, in beakers, on the hands, and even in the nostrils of a person; (*9*) instruments to measure the radioactive iodine in the thyroid; (*10*) octupi GM counter systems to be located about the doors and hallways, which would ring an alarm if anyone passed by with radioactive contamination on his person or clothing; and (*11*) various types of monitrons which record continuously on moving paper the radiation levels in various working areas of the plants.

The experimental research work of this section is extremely varied and ranges from rather routine tasks such as testing the various types of respirators for their efficiency in removing plutonium from the inhaled air to the more difficult investigations such as developing methods of detecting plutonium in the body and the more fundamental experiments of measuring neutrino and mesotron intensities in the neighborhood of the pile. Future investigations of the physicists with cyclotrons, betatrons, and other machines that produce high-energy radiation will present many new problems in Health-Physics research.

The principal function of the Personnel Monitoring sections is to determine the radiation exposure received by each person working on the Plutonium Projects. In keeping with this objective, special meters are made available to persons entering the various restricted areas. These meters consist of two pocket meters shaped like fountain pens which are small, low-leakage, air ionization chambers that are charged and worn during each work shift. These pocket meters are discharged in proportion to the radiation they receive and are read on a minometer at the end of each shift. They cover a range from about 0.02 to 0.2 roentgens. Another meter worn by the personnel is a film badge containing two special, dental-size films. One film covers a range from about 0.02 roentgens to about 3 roentgens, and the other can be used up to about 20 roentgens' exposure. The film badge contains an open window which permits the interception of beta rays and low energy gamma or X-rays. It is partially covered by a one-millimeter thick strip of cadmium (or silver) to harden the radiation and give a more accurate estimate of the more energetic gamma rays. At the end of the work shifts the films are developed and read with a photometer. Persons who work in the neighborhood of the piles wear, in addition to the regular films, a special neutron film which exhibits proton recoil tracks, and those tracks on the portion of the film behind the cadmium are proportional to the fast neutron exposure. These tracks on the films are counted by means of a dark-field microscope after the films have been developed. In addition to the above films, special film packets are worn in rings, in gloves, on the wrists, and on the forehead for special radiation exposure operations. Direct reading dosemeters are worn on especially hazardous operations where a day's tolerance exposure can be obtained in a few minutes. It is a rather stupendous task to distribute thousands of pocket meters and film badges each day; to read the pocket meters with a minometer; to develop and read the badge meters with a photometer; to interpret the readings; to record the radiation exposures; and to send out exposure reports to the supervisors. Special counters are used to measure body and clothing contamination, and decontamination laundries are oper-

ated for removing the alpha, beta, and gamma radiating materials from the clothing. Each garment is checked with counters before it leaves the laundry.

The work of the Health-Physics surveyor is not simply to measure the radiation level in a given area and then specify the safe working time. This is one of the surveyor's important assignments, but his responsibilities extend much further. The experienced surveyor is expected to work with the experimenter and to aid in designing experiments in such a manner as to prevent the development of hazardous radiation levels. The good surveyor is expected to have a clear understanding and a mature appreciation of the various operations in his area and to aid in solving the numerous radiation and decontamination problems as they develop. He must know where and when to look for radiation hazards. Experience has shown repeatedly that scientists, engineers, production men, and workmen are inclined to become so absorbed in their experiments and the operations at hand that they frequently forget about the insidious radiation hazards. The specialized operations of the Health-Physics surveyors have undoubtedly prevented many serious radiation exposures and probably have saved the lives of a number of the nation's important men. Nothing can look more innocent than a small 1,000-curie source of 1 Mev gamma rays, and yet it would probably cause the death of the person who inadvertently stands six inches from it for about two minutes.

The surveyor uses regularly about twenty different instruments. Most of the instruments were given special names because of security regulations. For illustration, a few of these instruments are: Chang and Eng, Lauritsen electroscope, Landsverk-Wollan meter, Parker Four-Fold counter, Zeus, Zeuto, Pluto, Cutie-Pie, Fish-Pole, X–22, Poppy, Teacart probe, and Walkie-Talkie probe. The surveyor must know which instrument to use and when to expect various types and combinations of radiation hazards. For example, he must know when to sample the air for radioactive gas, vapor, and dust; he must know if neutrons are to be expected and, if so, what neutron energies to expect; and he must know whether the radiation is uniform or localized in beams. The off-area surveyors must keep a constant check on the radioactivity of the air in the neighborhood of the plant to make certain that the radioactive xenon, argon, iodine, and suspended fission products do not at any time present a radiation hazard to the neighboring communities. A constant check must be made of the water drainage systems to guarantee that at all times the radiation level is such that it cannot harm the fish in the river systems or contaminate the drinking water of the cities downstream from the plants.

It is impossible to state the future of Health-Physics with certainty because the future of the field of atomic energy depends on several rather unpredictable decisions of this country and the constitution and decisions of a strong world government. We can speak of a future strong world government with considerable certainty because there is little doubt in this age of atomic bombs that it will come either by peaceful agreement, with the sacrifice of some national sovereignty and the strengthening and re-enforcing of the United Nations into a world federal government, or it will come by conquest and the world supremacy of the most powerful survivor of an atomic war. In any case, one is probably justified in predicting that there will be increased efforts in the field of atomic energy in this and other countries during the next ten years. During this period we might expect considerable increase in academic and development research at Clinton Laboratories, the University of Chicago, the University of California, and a few similar research

centers. In addition, cooperating groups of educational institutions[5] and large industrial concerns can be expected to make a strong bid in this field. Perhaps relatively small enriched uranium pile units can be developed and made available, at, let us say, fifty localities in this country to supplement research with cyclotrons, betatrons, Van de Graaffs, etc. We do not expect any great revolution in any of the industries in the coming decade, or that atomic energy will do more than supplement existing forms of energy, but we can believe that much industrial research will be done at various localities in developing atomic power units to furnish heat and electrical energy to isolated localities and to supply propulsion to submarines and surface ships. We would expect a large increase in the use of radioactive tracers for biological and medical research. These tracers may have considerable influence in the chemical, agricultural, steel, and petroleum industries. Many of the radioactive elements from the piles will be used in pure physics and chemistry research, and some of these elements may serve as a substitute for radium and its products in their numerous applications.

All these developments suggest the need for a considerable expansion of Health-Physics unless the nation and the world is to run the risk of catastrophic radiation damage and the death of many of the world's scientists during the coming decade. All the larger organizations that enter the atomic energy field should have their own Health-Physics departments, and the small organizations should be visited frequently by a Health-Physicist who would give necessary advice and instructions. In addition, the larger atomic energy organizations should employ the full- or part-time services of a radiologist. In general, the Health-Physics departments should report directly to the organization director or the director of health (if there is a director of health) and not work through Medicine, Biology, Physics, or any other department. Health-Physics, Biology, and Medicine should be parallel organizations, and one should not be combined with or subordinated to another; they should work with a maximum of cooperation, with the paramount objective of the protection of man from radiation damage. In case a radiation accident should occur in a small organization, the persons involved in the accident should be rushed to a radiologist, and Health-Physicists should be hurried to the site of the accident to make the necessary measurements and give proper instructions regarding evacuation and decontamination. As soon as it is suspected that a person may have received excessive radiation exposure, he should be turned over to the medical department, which takes full responsibility for the examination, care, and treatment of the patient.

These suggestions assume that there is an adequate supply of Health-Physicists and Health-Physics instruments. As a matter of fact, there is a scarcity of both, and this article is written primarily to call attention to this need. In order to meet the manpower requirements, an educational program should be set up at Clinton Laboratories and at other localities as the facilities and need arise. Already a large number of Health-Physicists have been trained at Clinton Laboratories for other sites. Such a training program should consist of two parts: (*1*) The training of Health-Physicists; and (*2*) the offering and sponsoring of a course in Health-Physics

[5] Already at the University of Chicago the Institute for Nuclear Studies, the Institute for the Study of Metals, and the Institute of Radiobiology and Biophysics have been organized for nuclear research. Similar programs are planned at the University of California and other universities. The Argon National Laboratory, the Park Ridge Institute of Nuclear Studies, and a still unnamed Regional Laboratory are in the process of organization.

to be given to all those who plan to enter the field of nucleonics, in order that they may develop the proper respect for radiation hazards. There is already considerable progress toward the establishment of an educational program in nuclear research at Clinton Laboratories in cooperation with a number of universities. Perhaps the Health-Physics educational program will become a natural part of this larger organization.

Another important general responsibility of our Health-Physics organization, such as the proposed organization at Clinton Laboratories and at the University of Chicago, should be to develop and supply Health-Physics instruments to the other organizations. It would not seem necessary or desirable that each of the Health-Physics organizations that may spring up over the country have its own research and development section or supply its own instruments. War experience has shown that industrial instrument organizations that are isolated from Health-Physics departments have not produced satisfactory instruments. Perhaps small research and development sections would be needed in some of the larger organizations to solve the problems peculiar to those plants, but in general it seems probable that an organization such as is proposed at Clinton Laboratories or at the University of Chicago would be able to supply most of the initial Health-Physics instrument needs and could furnish the nucleus of a trained Health-Physics personnel. In case of an explosion in an atomic energy plant or in the event of an atomic war, the need for Health-Physicists and their instruments would be very urgent, and they must be available on short notice.

The Health-Physics departments on the Plutonium Projects feel that their existence has been, and will continue to be, justified. So far as the Medical departments can determine and insofar as the Health-Physics instruments can measure, no one has received any radiation damage on any of the three Plutonium Projects. This statement is made with fingers crossed and with the realization that overconfidence or lack of vigilance could lead to great loss of life in a single day. Credit for the success of this program should be given to the 250 men in Health-Physics, and to the cooperation of the thousands of men in other departments. Special mention should be made of the assistance of the Medical Directors, J. E. Wirth at Clinton Laboratories, S. T. Cantril at Hanford, and L. O. Jacobson and J. J. Nickson at the University of Chicago.[6] Regardless of the trend of developments in the near future, there seems to be an ever-increasing need for Health-Physicists. Young men with college degrees and majors in physics should be encouraged to go into this field, and an educational program should be initiated to facilitate this training. In production plants, where the principal emphasis is placed on personnel monitoring and plant survey, a physics background is less important than it is in a research institution, and experience has proved that high-class chemical engineers can be trained to become excellent Health-Physicists for radiation survey assignments. Also chemists, biologists, engineers, and other technical personnel should consider training for various assignments in this new field of Health-Physics. The efficiently operated Health-Physics organization at Richland, Wash., should serve as a model for that of other large plants producing atomic energy.

[6] A few of the Health-Physics group leaders who also deserve special mention are W. H. Ray, R. H. Firminhac, L. J. Deal, and R. R. Coveyou at Clinton Laboratories, F. R. Shonka and O. G. Landsverk of the University of Chicago, and C. C. Gamertsfelder, J. C. Hart, C. M. Patterson, and Jack Healy of Hanford.

WHAT SOUND HATH WROUGHT—I*

By NATHAN LEVINSON
WARNER BROS. PICTURES

TWENTY years ago, on the evening of August 6, 1926, a critical New York theater audience viewed and approved the initial exhibition of the world's first commercially successful sound motion picture. Preceded by a screen address by Will Hays and a series of sound short subjects featuring such artists as Marion Talley, Anna Case, Martinelli, Mischa Elman, and Zimbalist, the first feature sound picture, *Don Juan,* brought its own orchestral accompaniment to the screen through the medium of Vitaphone recordings, which were reproduced in exact synchronism with the picture. Thus, after months of most intensive preparation, the Warner brothers presented to the public a new medium of entertainment, which was shortly to bring an end to the era of silent motion pictures.

Some six months later William Fox demonstrated results which had been achieved by the photographic recording of sound on film, and shortly thereafter he introduced the Fox Movietone Newsreel employing a photographic sound track. On October 5, 1927, the Warner Brothers Vitaphone Corporation released *The Jazz Singer* starring Al Jolson, containing the six spoken words which electrified the industry. Judged in the light of events which followed, the success of *The Jazz Singer* apparently provided the proof necessary to the major motion-picture producers of Hollywood that sound pictures had come to stay, and plans for the construction of soundproof stages and the installation of sound-recording equipment were rushed to completion with a wholehearted disregard for costs. Engineers, technical advisers, and technicians were rushed to Hollywood from the East to assist in the revolution of the motion-picture industry. Manufacturers of sound-motion-picture recording and theater equipment worked extra shifts in an attempt to meet the sudden demands of a new industry. By the end of 1928 a total of sixteen sound-recording channels had been installed in Hollywood; by the end of 1929 this number had grown to at least one hundred and sixteen. New motion-picture production techniques were developed overnight. The Academy of Motion Picture Arts and Sciences established a sound school which provided instruction in the new art of motion-picture sound recording to more than nine hundred men. Schools of voice culture grew in sheer profusion, motivated by a desire to assist, for a price, those stars of the silent screen whose vocal prowess was somewhat inferior to their mastery of the art of pantomime.

LEST it be assumed that the sound motion picture was the result of a single and spectacular technical achievement, it should be pointed out that it was brought to a state of practical realization largely through the simultaneous development of a number of rather unrelated discoveries in the field of pure science. Numerous attempts to exhibit sound motion pictures were made between the year 1878, when Wordsworth Donesthorpe suggested the idea of talking photographs, and the year 1924, when

* Copyright, 1946, by Nathan Levinson. This article was obtained through the cooperation of Mr. Charles S. Steinberg, of Warner Bros. Pictures, the company that is now celebrating the twentieth anniversary of its successful introduction of sound motion pictures.—Ed.

the Bell Telephone Laboratories demonstrated its newly perfected motion-picture recording and reproducing systems. With few exceptions, the failure of the various systems proposed and experimentally constructed during those early years was due to a lack of one or more of the elements considered essential to any modern recording and reproducing system.

The practical beginnings of the talking picture date back to the year 1877, when Thomas Edison announced his development of the phonograph. It was within a year of that date that Donesthorpe suggested the talking photograph. In a letter to *Nature,* which was published in the issue of January 24, 1878, Donesthorpe stated:

> By combining the phonograph with the Kinesigraph I will undertake not only to produce talking pictures of Mr. Gladstone which, with motionless lips and unchanged expression, shall positively recite his latest anti-Turkish speech in his own voice and tone; not only this, but the life-size photograph itself will move and gesticulate precisely as he did when making the speech, the words and gestures corresponding as in real life.

Donesthorpe took his photographs at intervals of approximately ¼ second, with an exposure of ⅛ second, which probably accounts for his use of the phrase "with motionless lips and unchanged expression." Unfortunately, the Edison phonograph of 1880 had not been brought to a high state of perfection, and nothing came of Donesthorpe's experiments.

Although the production of photographic sound records presented numerous difficulties not inherent in the mechanical process of recording, it is interesting to note that Charles E. Fritts, on October 22, 1880, filed a patent application which covered a variety of photographic sound records, several of which are basically similar to modern motion-picture sound track. Fritts proposed that these sound records might be reproduced by causing a narrow beam of light to pass through the moving sound record and then to fall upon a selenium cell, which would regulate an electric current and thus operate a diaphragm. Fritts' patent was finally issued on October 21, 1916, a full thirty-six years after it was first embalmed in the archives of the United States Patent Office.

Contrary to popular impression, it was not the development of motion pictures that gave rise to a desire for an accompanying sound record, but the development of the phonograph that led Edison to the idea that "it was possible to devise an instrument that would do for the eye what the phonograph does for the ear, and that by a combination of the two all motion and sound could be recorded and reproduced simultaneously." Edison pushed the development of his motion-picture machine and by April 1894, with the aid of some of George Eastman's first strip film, produced sound motion pictures of the peep-show variety.

Although the Edison Kinetophones, as these peep-show devices were called, were not commercially successful, he continued the development of his equipment and, by the year 1908, had produced a sound-picture system designed for use in the comparatively large film theaters which by that time had made their appearance. This theater system consisted primarily of a motion-picture projector, which was located at the rear of the theater, and a phonograph, which was located on the stage and driven in approximate synchronism with the projector by means of a long wire belt. This system seems not to have created any widespread public interest and effectively disappeared from the scene within a few years from the date of its introduction.

The period between the years 1900 and

1924 witnessed a number of significant experiments directed toward the achievement of satisfactory reproduction from disc and film sound records. Prominent among the pioneers in sound-picture development are the following men: Ruhmer, who experimented with means of photographing a voice-modulated arc light on motion-picture film; Poulsen, who developed a method of magnetic sound recording on a steel ribbon; Gaumont and Lake, who experimented with various systems for synchronizing phonographs and projectors and who also suggested the use of loud-speakers behind the theater screen; Amet, who employed electrical pick-up methods for recording; and Lauste, who pioneered in the development of methods for recording the picture and sound on the same strip of film. In the latter years of this period such names as Case, Hoxie, and De Forest were added. A study of the patent literature of that period reveals that the number of investigators engaged in the development of recording, reproducing, and synchronizing methods was exceeded only by the diversity of their ideas on satisfactory methods of accomplishing their objectives.

Of the hundreds of early experimental attempts to develop a satisfactory sound-motion-picture system little remains today. Without exception, each of the proposed systems was deficient in one or more important respects when judged by the form of the first commercially successful equipment. Edison's principal contributions, of course, were the development of the phonograph and the motion-picture machine; his actual attempts to produce commercial talking pictures have had no noticeable influence on later developments. Fritts indicated a variety of sound photographic records and means for reproducing these. Several of his proposed types of sound track are in widespread use today, but his system of reproduction was wholly inadequate to meet commercial theater requirements and had no perceptible influence on the development of modern reproducing equipment. The invention and development of the telephone was, on the other hand, essential to the practical achievement of sound motion pictures, as were the invention and development of the electron amplifier tube, the photoelectric cell, and the loud-speaker. The modern sound motion picture is actually a hybrid of developments in such fields as electronics, acoustics, chemistry, mechanics, optics, and metallurgy.

It would be impossible to properly assess the value of contributions made by individual inventors to the sound-motion-picture industry. Much of the necessary research and development work essential to the evolution of modern commercial recording and reproducing systems has been conducted in the laboratories of our larger industrial organizations. In particular the Bell Telephone Laboratories and the research divisions of the General Electric Company, the Westinghouse Electric Company, and the Radio Corporation of America may properly be credited with the fundamental and major contributions to the art.

Although the first commercial sound-motion-picture equipment emerged from the laboratory in the year 1926, a continued program of research and development, leading to the improvement of equipment originally installed in the Hollywood studios and in the theaters throughout the country, has been maintained. Additional development work, stimulated by the problems encountered in adapting recording and reproducing equipment to the ever-changing needs of the motion-picture industry, has been carried on in the major motion-picture studios of Hollywood.

The first commercial sound-picture records were derived from recordings made upon finely polished soft wax blanks. After suitable processing of these waxes, a "stamper" was produced which permitted the production of quantities of release records in the form of sixteen-inch discs, similar in all respects save size to those utilized with the home phonograph. Each disc record carried an engraved start mark, which permitted its proper synchronization with a corresponding reel of picture in the theater projection machine.

At the time of the introduction of sound motion pictures the technique known as dubbing, which consists of combining portions of a number of individual records into a single final release record, had not yet been developed. It was necessary, therefore, to so arrange all the elements involved in the production of a picture that photography and recording might proceed continuously for the period of eight to eleven minutes required to complete a single reel of picture. When more than a single scene was included in a reel, it was necessary to provide the requisite number of motion picture sets adjacent to one another and to secure smooth sound and camera "dissolves" from one scene to the next without halting the recording machines or cameras. This situation imposed almost intolerable production restrictions, and means were soon developed which permitted electrical re-recording of portions of a number of individual original records to a final release record, without loss of synchronization between sound and picture at any point of the process.

Between the years 1928 and 1931 disc recording gave way to photographic recording on motion-picture film, and with this transition the most severe handicaps imposed upon motion-picture production by the advent of sound were eliminated.

ALMOST all motion-picture production techniques have undergone extensive modifications since the transition from silent to sound picture releases, and a review of some of the changes wrought by the introduction of sound may prove of interest.

The motion-picture industry has long been symbolized in the minds of the movie-going public by cartoons of the motion-picture director with megaphone raised to his lips. It is difficult to state whether the megaphone represented a necessary accessory to the direction of silent pictures or whether it served merely as a badge of honor, but it is known that the noise levels encountered on stages employed for the production of silent motion pictures was of such an order as to preclude the production of sound pictures. The silent-picture stages were, in most cases, of relatively light construction, since they were designed primarily as a shelter for interior sets and to permit the attainment of a degree of lighting control which could not be secured in the open. As a general rule exterior sets were built in the open and in any location which might prove convenient from a production standpoint. Noise, as such, was troublesome only to the extent that it might be considered annoying to the artistic temperaments engaged in the production of a picture.

With the introduction of sound recording the elimination of extraneous noises from the motion-picture set became a matter of vital importance to production. It was necessary, therefore, either to modify the construction of existing stages so as to provide complete freedom from traffic and other exterior noises or to construct stages specifically designed for the production of sound pictures.

Modifications to existing stages consisted primarily of soundproofing the walls and ceilings and eliminating squeaky floors. New stage designs pro-

vided for structures which were inherently rigid and sufficiently well insulated to provide very high attenuation to all sounds transmitted through the walls and ceilings. The necessary insulation was generally obtained through the use of laminated walls which consisted of alternate layers of rigid and porous materials, separated by air spaces. Flaxlinum, celotex, and rock wool were widely used as insulating materials, and it is interesting to note that the sudden demand for huge quantities of these materials stimulated the expansion of manufacturing facilities for their production. Few of the new stages had more than two large doors, and these were of laminated construction similar to that employed for the stage walls. While the size of the various new stages differed considerably, a typical sound stage provided a floor area approximating 30,000 square feet, the average structure being of the order of 225 feet in length, 135 feet in width, and from 35 to 50 feet in height.

The amount of power required for set lighting purposes during the early years of sound recording was rather appreciable, three to four thousand kilowatts being employed for many of the larger sets. In view of the fact that more than 95 percent of this power was converted into heat, adequate stage ventilation was essential. A number of stages were equipped with air-conditioning plants, while others employed large roof ducts which were suitably lined with felt or other sound-absorbing materials.

Acoustic treatment of the interior stage walls was generally such as to minimize reverberation effects to the point where these were not troublesome. It has not been customary to provide adequate acoustic treatment on sound stage walls to permit high-quality recordings on empty stages.

The earlier forms of studio sound-recording equipment were far from portable. The microphones and their associated amplifiers, mixer equipments and booster amplifiers, and monitoring amplifiers and loud-speakers were installed on the stages, while the main recording amplifiers, recording machines, power supplies, and auxiliary apparatus required for the sound-recording channel were located in central recording buildings. Underground circuits were employed to connect the equipment used on the stages with that in the recording building. Thus, each stage had to be equipped with numerous signal, power, and communication circuits and with suitable terminations for these circuits at a number of points on the stage. The microphones and their associated amplifiers were so located on the actual set as to permit the best possible pick-up of voices and such incidental sounds as were required for the scene being photographed. The remainder of the stage equipment was at first located in so-called monitor rooms, which housed the sound-mixer equipment, amplifiers, monitoring loud-speakers, and such other auxiliary apparatus as were necessary to permit proper control of the signals being transmitted to the central recording building.

In a number of cases these monitor rooms were constructed at a sufficient elevation above the stage floor level so that the sound mixer, who controlled the over-all signal level and combination of sounds from the several microphones employed, would have an unobstructed view of the set engaged in production. It was soon found, however, that the view from these monitor rooms was frequently blocked by large set structures, and accordingly the use of monitor rooms soon gave way to portable monitoring booths which could be placed immediately adjacent to the set being employed.

One of the greatest difficulties encoun-

tered in the production of satisfactory sound records was caused by the various noises originating on and about the motion-picture set proper. Perhaps one of the worst offenders in this respect was the motion-picture camera itself, whose constant whirring was not only audible but in many cases tended to blanket the dialogue picked up by the microphones. The first solution to this problem took the form of soundproof booths, large enough to house one or two cameras and the cameramen who operated them. A total of three or four such camera booths might be employed in the photography of a single scene.

As increased production freedom was provided through the development of improved sound-recording equipment, and in particular with the displacement of disc recording by film recording, the restrictions on camera operation imposed by the camera booths became intolerable. Practically full freedom of camera operation and manipulation was regained during the year 1929 by the use of housings, known as camera blimps, which completely enclosed and soundproofed the camera but permitted its operation on standard tripods, dollies, or cranes. Somewhat later, further improvements resulted from developments by motion-picture camera manufacturers who bent their efforts to the production of inherently silent camera mechanisms. As a result of this program, and after years of laboratory and studio experimental work, the modern professional motion-

EARLY MOTION–PICTURE SOUND EQUIPMENT

A TYPICAL OFF-STAGE SETUP IN 1926 FOR THE FILMING OF A SCENE. NOTE THE OLD-FASHIONED, OVERHEAD, CARBON-TYPE MICROPHONE AND THE MOTION-PICTURE CAMERA INSIDE THE SOUNDPROOF BOOTH.

picture camera is so quiet in operation that it can be operated on any indoor motion-picture set without the aid of auxiliary soundproofing enclosures.

The modifications of the camera mechanism necessary to subdue noises generated by gear trains, intermittent mechanisms, motors, and the passage of film through the camera have also greatly improved the quality of the photographic image and the clarity and steadiness of the picture viewed on the theater screen. Here, then, is evidence of several very desirable improvements which were at least initiated by the introduction of the talking picture.

The motion-picture negative film employed at the time of the introduction of sound pictures was of rather low sensitivity as compared to the modern product, and large banks of arc lamps were generally employed for set illumination. The operation of these lamps was accompanied by intermittent sputtering noises, squeaks and groans from the carbon driving motors and mechanisms, metallic popping noises caused by expansion and contraction of the lamp housings due to high thermal gradients, and whining noises characteristic of the commutator ripple originating in the generator sets which supplied power to the lamps. Hasty remedies were improvised for removing most of the noise produced by the operation of lamp mechanisms, and various forms of large and clumsy choke coils and other filter devices were utilized to subdue the whine produced by commutator ripple. Only a moderate degree of success was attained, however, and experiments leading to the utilization of incandescent set lighting were hastily initiated. All types of incandescent lighting equipment were exhaustively tested by studio technical personnel, assisted by engineering representatives from the large incandescent lamp manufacturers. Warner Brothers Studio, which was pioneering in the development of talking pictures, offered its studio facilities to members of the American Society of Cinematographers in order that the necessary photographic tests might be made to establish a basis for the attainment of satisfactory photographic quality. During one period of sixty days over three hundred cinematographers assisted in experiments and attended demonstrations leading to the development of incandescent set lighting.

The largest incandescent lamps available at the time of these experiments were 1,000-watt units, and these were employed individually and in banks to secure the necessary illumination levels. Somewhat later, 2,000-watt lamps, employing a monoplane filament and prefocused bases, were developed to meet the specific needs of the motion-picture industry. Five- and ten-thousand-watt lamps, employing bipost bases, were developed at a still later date. These lighting units proved so satisfactory that arc lamps were employed only when it was necessary to provide the high lighting intensities required for color photography or for black-and-white production scenes requiring the high illumination levels or sharply outlined shadows which only arc lighting can provide. It should be added that continued development of arc lamps and properly designed filter networks for the elimination of commutator ripple have relieved most of the objections to the use of these lamps, and, in view of their superiority over incandescent lamps for certain lighting applications, they are still widely employed in the industry. During the year 1942 a suitable compact filter was developed at Warner Brothers Studios which efficiently and completely eliminates all commutator ripple noise from arc lamps in service. Thus, the introduction of sound recording forced rather revolu-

tionary changes in the techniques and equipment employed for motion-picture set lighting.

During recent years film manufacturers have succeeded in so improving the sensitivity of motion-picture negative stocks that present-day set lighting intensities are comparable with lighting values employed in many commercial operations. A pronounced trend toward the use of low wattage spotlights, in conjunction with main lighting elements employing 1,000- and 2,000-watt lamps, has resulted in a very appreciable reduction in the amounts of power required for set lighting as compared with that used twenty years ago.

The character of the sets required for the production of sound motion pictures was materially different from that suitable for silent productions. The nature of the materials employed for the construction of silent-picture sets was dictated largely by the cost and availability of materials and the nature of the illusion which might be created through their use. With the introduction of talking pictures it became necessary to consider the acoustic qualities of the materials employed and to avoid set structures of such configuration as would produce resonances or reverberation effects. It was essential, for example, to minimize the use of alcoves and arches and to avoid wherever possible the construction of sets with deep window recesses. Pronounced reverberation effects were also evident in sets constructed with vaulted ceilings, unless these were fabricated of muslin. The use of beamed ceilings was avoided wherever possible, for it was necessary to provide adequate space above the set for unrestricted movement of the recording microphones.

For a time it was believed that set walls should be almost entirely constructed of cloth, and a great many were so constructed. Within recent years walls have commonly been constructed of plywood mounted in suitable wooden frames, the objection to continued use of cloth walls arising largely from the fact that they have no salvage value, nor do they provide the rigidity so often essential in set construction. In order to avoid the flutter of cloth set walls it is necessary to provide suitable reinforcing backings of wood. These backings are also required whenever objects, such as pictures and clocks, must be suspended from the walls.

The rather loud and frequently boomy sounds of footsteps on the hardwood stage floor have been reduced to inaudibility through the use of broadfelt floor coverings. Materials such as celotex have found a great variety of applications in set construction, being employed, for example, in place of concrete for building exteriors, sidewalks, and flagstones. Many of the most massive structures viewed on the screen of the motion-picture theater are built of such comparatively fragile materials as papier-mâché, fabrics, and plywood. The choice of the materials employed is, of course, based upon a number of considerations, among which might be included mechanical strength and rigidity, ease of fabrication, cost and availability of materials, size of the structure involved, freedom from panel vibration and other objectionable acoustic characteristics, and suitability from a photographic standpoint.

Some idea of the magnitude of the single task of designing and fabricating sets for one of the major motion-picture producers may be gained from the number of studio employees engaged in this work. The production of twenty feature pictures a year requires the full-time services of an average of fourteen art directors, twelve sketch artists, seven model builders, thirty set designers, one

hundred and fifty carpenters, one hundred and twenty-five painters, forty machinists, and approximately one hundred men who are engaged in crafts involving smaller numbers of workers.

A number of the departments now of major importance to the operation of a modern motion-picture studio were scarcely in existence prior to the advent of sound. One of these is the Story Department, whose function is that of securing suitable material for the production of the large number of feature pictures and shorts which are released each year. Silent motion pictures were often shot with incomplete scripts and in many cases without the benefit of any script at all. A clever director and cinematographer could undertake the production of a feature picture with a script which provided only the general framework of the story involved. Such dialogue as might be incorporated in the script was relatively unimportant, since titles were used to convey such information to the theater patron as could not be readily gained from the action involved in the picture.

This method of production required radical modification with the introduction of the sound picture. In the first place, the dialogue involved was, in many cases, of equal or greater importance to the sense of the story than the action of the players, and it became necessary to prepare production scripts complete to the smallest detail to permit satisfactory direction of the picture. A complete script was also essential in order that the studio Art Department might undertake the design of sets suitable for production of sound pictures.

The entire presentation of the average feature production has taken on a lifelike quality which was completely absent in the exaggerated pantomime of the silent picture, and characters appearing on the screen have assumed a degree of realism which was impossible in silent pictures. The scope of material suitable for screen presentation as sound pictures is enormously greater than that which could similarly be employed in silent presentation, and many situations whose entire significance is conveyed through dialogue may now be successfully portrayed. Many stage plays which were formerly beyond the scope of the motion picture have been made into very successful sound pictures. The comedy of action has generally been replaced by the comedy of wit. Many situations may be successfully portrayed without dependence upon either dialogue or action, but solely through the use of cleverly employed sound effects.

The modern Story Department maintains very elaborate files of synopses of practically all the publications in the field of fiction and employs a staff of experts to continually survey the several literary fields. The preparation of production scripts is frequently entrusted to writers with world-wide reputations, who are assisted in their efforts by Story Department personnel acquainted with the restrictions imposed by production codes and the general limitations of the medium. When detailed information with respect to some phase of preparation of the script is required, the studio Research Department is consulted. It can make available on short notice complete information with respect to the life, dress, habits, customs, beliefs and prejudices, housing, social and business activities, government, and past history pertaining to practically any community or people on earth. It is through such means that the authenticity of situations and characters depicted in many historical pictures is assured.

(To be concluded)

DOES THE STING RAY STRIKE AND POISON FISHES?

By E. W. GUDGER

AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK

IN ANOTHER paper (1944) I have assembled and discussed in monographic fashion all the evidence available from classical times to 1932 that sting rays wound, poison, and occasionally cause the deaths of men. In another and shorter article now in press, I have summarized Vellard's experiments (1931, 1932) with spines from certain fresh-water sting rays which abound in the Araguaya River in South-Central Brazil. With venom from these spines, he experimented on dogs, mice, rabbits, guinea pigs, birds, lizards, frogs, and toads. These were all poisoned, and many died as a result of the infections. These very interesting experiments seem to be the only ones ever made wherein the poison of the sting ray has been tried out on vertebrates or indeed on any animals. Therefore it is of no small interest to ascertain whether rays sting other fishes and whether fishes so stung are poisoned. These questions apply not only to the great group of teleosts, or bony fishes, but to the elasmobranchs, or strap-gilled fishes, including sharks and rays themselves.

BONY FISHES

The ray's sting is an organ of defense only, never of food-getting. Yet I can quote two old-time authors who thought that the sting was used to catch bony fishes for food. Thus Pliny (23 B.C.–A.D. 79) says in his *Naturalis Historiae* (Bk. IX, Chap. 67) that "The *Pastinaca* [Mediterranean sting ray] lies lurking in ambush and pierces the fish as they pass with the sting with which it is armed." And the eminent early French ichthyologist Guillaume Rondelet in his book *De Piscibus Marinis* (Lyons, 1554) speaks of the Trygon with its spine pointing backward but with the teeth pointing toward the ray's head. Then he says that ". . . when the ray has stung a fish, the spine holds it like a hook."

These statements by Pliny and Rondelet were mere inferences drawn from the presence of the barbed spine on the tail of the ray. No writer since Rondelet's time has alleged that the spine is an organ for the prehension of food. It should be noted that the ray's small ventral mouth and its flat body fit it for bottom dwelling and feeding. It feeds on worms (its chief food in my dissections), clams, and crustaceans—all small bottom-dwellers. An occasional small fish may be taken in, but fishes cannot be considered as its steady diet. Moreover, it is notable that sting rays taken in pound nets along with great numbers of bony fishes have never, so far as the records go, had any fish remains in their stomachs.

It has been alleged, however, that one of the stingless rays, *Mobula,* feeds on fishes. It was described to me by the observer as forming with its unrolled "horns," or cephalic fins, a kind of funnel and then swimming into and through a school of small fishes. The funnel directed these fishes into its huge mouth. Probably this habit of feeding is common to the other Cephaloptera, or stingless rays with cephalic fins.

So far as I know, there is no record of a sting ray striking a bony fish. This

might happen if the bony fish surprised a ray, but I cannot imagine an intentional stinging. Furthermore, no experiments with fresh sting ray spines seem ever to have been made on bony fishes. If and when this is done, one may surmise that the bony fish would be poisoned. Here is a field for interesting experimentation.

Rays

There is also no record known to me that any of the rays have ever been stung by a sting ray. I have handled and dissected scores of sting rays and stingless ones without ever finding a ray that showed any evidence that it had been stung. These rays must compete for the same food; they are found in groups and are not averse to using their stings in defense. But the record of any use of the spine on another ray is blank. No one knows whether the stinging of a ray would be followed by poisoning. Here is another opportunity for experimentation. This blank record for rays is all the more surprising in the light of what is to follow.

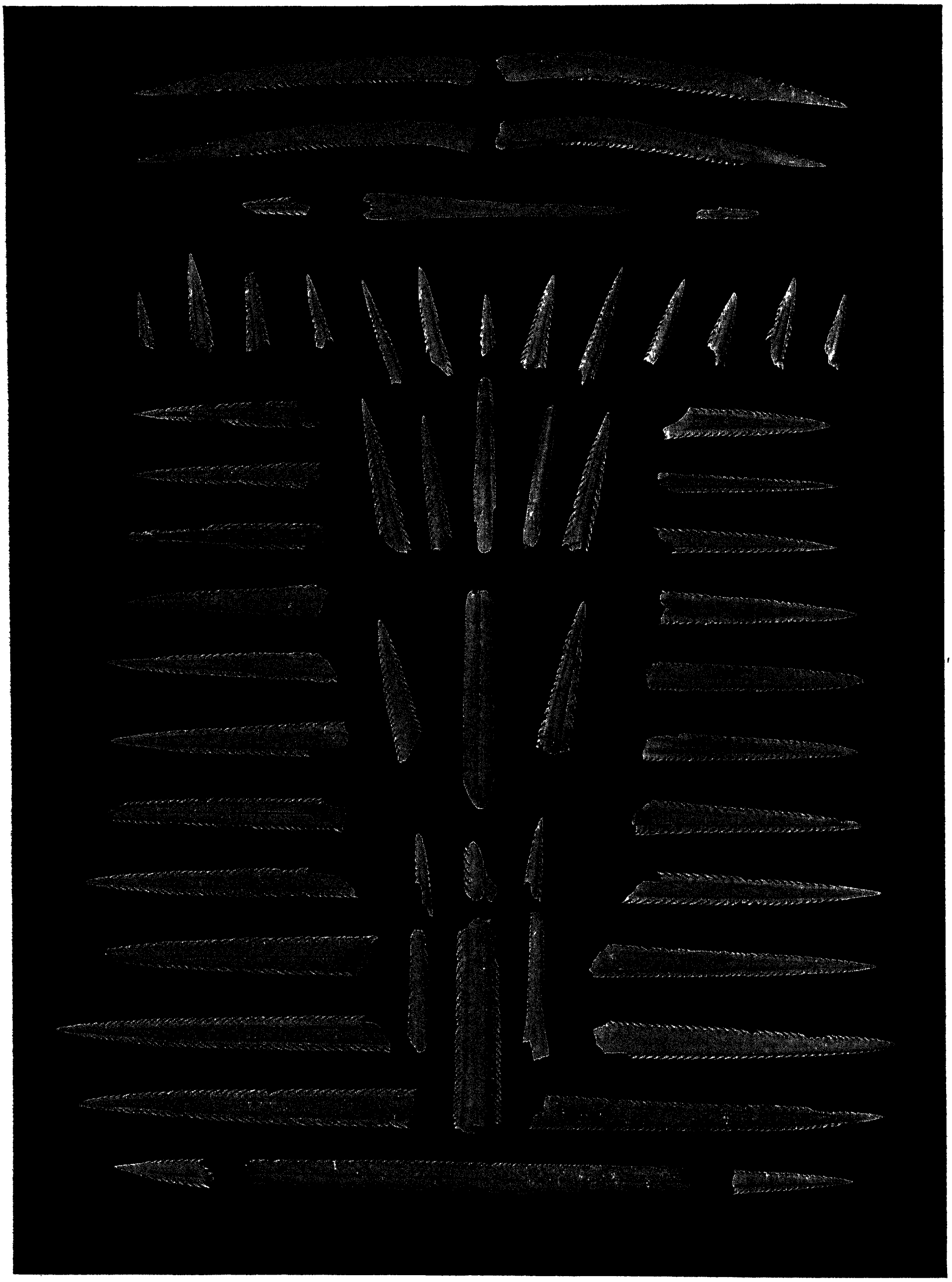
Sharks

My personal experience with sting rays and sharks began in the summer of 1902 at the U. S. Fisheries Laboratory at Beaufort, N. C., and continued there for ten seasons; it was further continued for four seasons more at Key West and at the station of the Carnegie Institution of Washington, at Tortugas, Fla. Sting rays and sharks were being sought for the study of their reproductive organs and their methods of reproduction. I was warned of the violence of the rays and of the virulence of their stings by my fishermen friends. In my ignorance, I supposed that all the water vertebrates as well as man were susceptible to poisoning by rays. That sharks were stung but not affected was not ascertained by me until 1906.

It is known that at least four species of sharks—the hammerhead, the black-tipped, the sharp-nosed, and the tiger shark—are stung but not poisoned by rays. The evidence will now be presented.

Hammerhead No. 1. On July 20, 1906, a huge hammerhead shark (*Sphyrna zygaena*) was seen chasing large sting rays over the sand flats in Beaufort Harbor. Rays and shark swung near an anchored fishing boat, and the shark (12 ft. 6 in. long) was secured with a harpoon. The next day I purchased the shark (a female), towed it to the wharf of the Bureau of Fisheries Laboratory, hoisted it by a derrick, and dissected the viscera. In the stomach was found an almost perfect skeleton of a sting ray, together with fragments of the skeletons of other like victims. In cutting the skin away from the muscles (one cannot husk the hide off a shark as from an ox) I found stings abundant in the throat and jaw region. Night came just when the skin had been literally dissected from the body muscles, and further work was stopped.

Next day, 40 hours after capture of the shark, the jaws were dissected out, even though the shark was in pretty "high" condition, and cleaned up for preservation as a museum specimen. In this dissection 54 fragmentary sting ray and 4 ocean catfish stings were found in the neck region and in the muscle masses adherent to the jaws. In the neck region some of the stings were embedded in tissues still suffused with blood, showing that the wounds were recent. Others, especially those piercing the membranes covering the jaw cartilages, were embedded in cysts, showing that they were from old stingings. Furthermore, the jaw cartilages were scarred and ridged —evidently the result of long-past combats. These jaws and adjacent parts were a real mine of stings, and yet this hammerhead was alive, unhurt, and a



After Gudger, 1932

FIG. 1. SPINES RECOVERED FROM A HAMMERHEAD SHARK

EXCEPT THE 4 PECTORAL SPINES OF THE OCEAN CATFISH AT THE TOP, ALL ARE SPINES, OR STINGS, OF STING RAYS. ALL 58 WERE DISSECTED FROM THE JAWS AND NECK REGION OF A HAMMERHEAD SHARK.

veritable dynamo of energy when harpooned. Figure 1 shows these stings arranged in a panel.

Sting rays had surely been a favorite food of this particular hammerhead. When caught in the shark's jaws, each ray had in defense lashed out with its long tail, and at least 54 of them had left with the shark mementos of their fights. Figure 2 is an excellent portrayal of *Dasyatis centrura,* a typical sting ray found at Beaufort and ranging north along our Atlantic coast. Note the two spines set some distance out on the tail, giving the ray a considerable striking radius and force. Probably rays of this species are responsible for some of the spines shown in Figure 1.

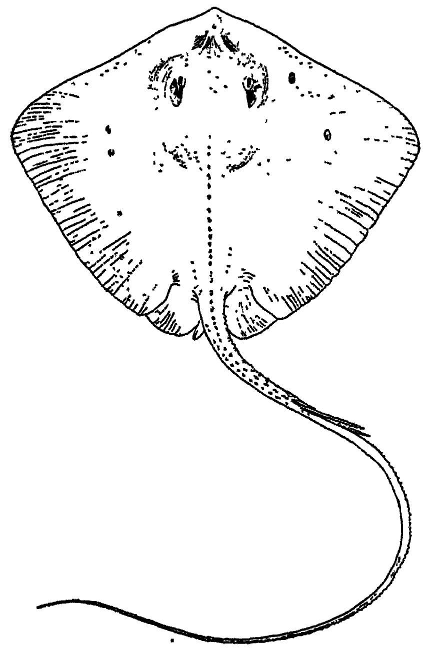
Hammerhead No. 2. Just 20 years after I made the observations set out above, Mr. Henry W. Fowler (1926) wrote of a hammerhead shark, 13.2 feet long, taken at Captiva Pass, West Coast of Florida:

> In the stomach . . . were three rays . . . with a disc length of 18 to 24 inches, and in the mouth one ray of 20 inches. There were remnants of 17 caudal spines in the stomach. . . . The jaws were punctured with other spines and at least 24 spines were in the gums.

Had jaws, neck, and chest region been dissected, many more than the 24 spines would probably have been found. Yet this shark with 17 spines in its stomach and 24 in the jaws was very much alive when captured. Its taste for rays, like that of hammerhead No. 1, was certainly well developed.

From these two detailed accounts, it is clear that sting rays are probably the favorite food of the hammerhead shark, and it seems clear that these sharks are not susceptible to the poison of the sting.

The Black-tipped Shark. The American Museum possesses a considerable collection of dried shark jaws, among them one from a black-tipped shark (*Carcharhinus limbatus*) taken at Djibuti, on the Gulf of Aden. This pair of jaws had been merely "roughed out," salted, and dried. Some years ago I had occasion to carefully dissect off this dried muscle tissue and clean these jaws for photographing. From them 13 stings were obtained. In the lower left jaw a sting



After Hildebrand and Schroeder, 1928

FIG. 2. A STING RAY

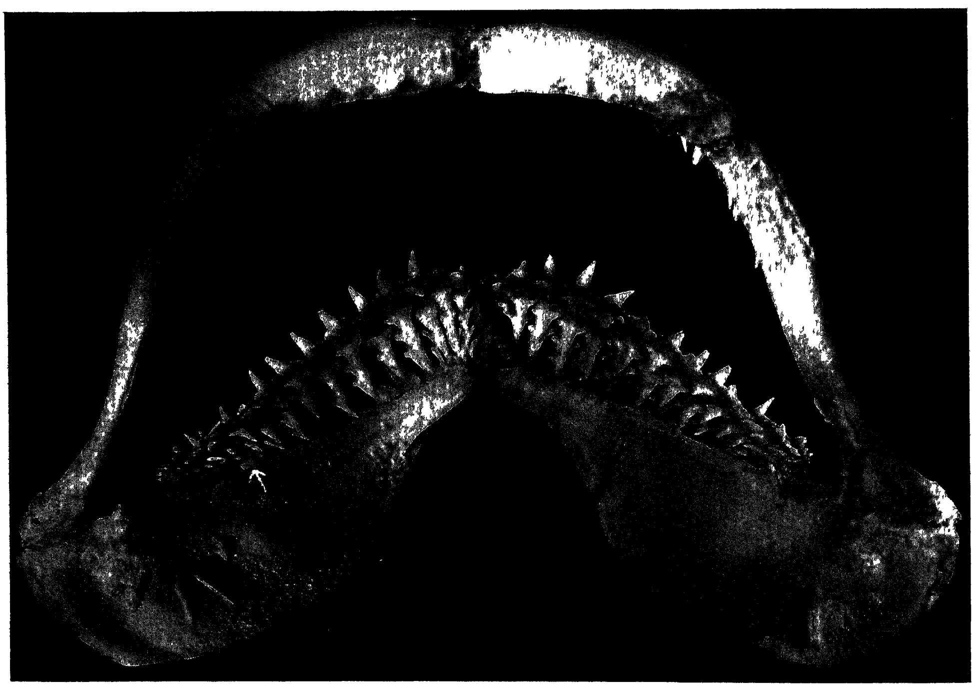
THIS SPECIES, *Dasyatis centrura,* OCCURS FROM BEAUFORT, N. C., NORTHWARD ALONG THE ATLANTIC COAST. NOTE POSITION OF THE TWO SPINES.

was found which had been driven into the "gum" of the jaw; that is, into the fold of tissue covering the rear (young, or "baby") teeth of the shark (Fig. 3). This sting had penetrated the big jaw cartilage, and the point protruded on the outside of the jaw. This shows what a heavy stroke a large ray is capable of inflicting. Other spines were found stuck in the membrane of the left lower jaw, and 5 spines in the gums and membrane covering the right lower jaw.

Some of these are seen affixed to the inner side of the lower jaw (Fig. 3). One sting, indicated by the arrow, had split the tooth bud, and from the bifurcated tooth germ two sets of half-teeth had grown. There are at least four rows of these half-teeth present. How many had been broken off in front in the course of time cannot be determined, nor can one say how long it takes a single pair to develop. But plainly this shark had lived years since the spine became embedded in its left lower jaw and since all the other spines had accumulated. Evidently it was immune.

The Sharp-nosed Shark. In 1919 Dr. R. C. Murphy, of the American Museum, captured a specimen of the sharp-nosed shark (*Scoliodon terrae-novae*) off Sanibel Island, West Coast of Florida, and sent the jaws to the Museum. In the left lower jaw was found the tip of a sting embedded in the tissues covering the jaw. If at the time of capture a hunt had been conducted for other stings in the jaws and the throat region of this shark also, there is a strong probability that such would have been found. This shark, like the others, seems immune to the poison of the sting ray.

The Tiger Shark. There is one other identified shark known to be a sting ray eater. This is the well-known tiger shark (*Galeocerdo tigrinus*) with the sickle-shaped teeth. In 1784 William Andre published a drawing (Fig. 4) showing a sting ray spine embedded in the gum of a jaw. It had split the tooth germ into halves and had done this so long ago that at least 6 pairs of half-



After Gudger, 1932

FIG. 3. A SHARK'S LOWER JAW SEEN FROM BEHIND

CEMENTED TO THE JAW CARTILAGE OF A BLACK-TIPPED SHARK ARE SOME OF THE 13 STING RAY SPINES FOUND IN THIS SPECIMEN. THE ARROW POINTS TO A STING EMBEDDED IN "GUM" CARTILAGE.

teeth had developed into full size, as the figure shows. Years must have been necessary for this.

Just 137 years later, corroboration was obtained that the tiger shark is an eater of rays. In 1921 Bell and Nichols recorded the finding of fragments of sting rays in the stomachs of two tiger sharks caught at or near Cape Lookout on the North Carolina coast. The presence of stings, if any, in the mouth parts was not noted since no dissection of the jaws was made.

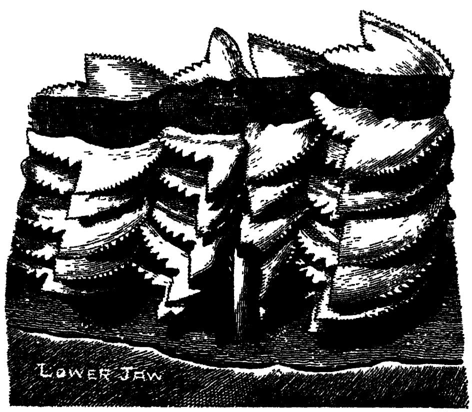
I have seen tiger sharks chasing sting rays in the waters about Key West, Fla., and there and at Dry Tortugas I have dissected a considerable number of these sharks but, being particularly interested in the reproductive organs, I unfortunately made no search for stings. However, the above citations clearly show that these tigers of the sea are feeders on rays and are seemingly impervious to the poison of their stings.

Sharks in General. Capt. W. E. Young has been connected with shark fisheries all around the world and, as an outcome of his long experience, has a large knowledge of these fishes. He has kindly communicated the following résumé of his observations on sharks feeding on rays and being stung by them:

> Sharks everywhere seem fond of rays and may be found feeding on them. These rays are all provided with from one to five sharp stingers of bone with barbs pointing backward. These stingers inflict terrible wounds on human beings, but though the ray stings the shark when it catches and eats the ray, the stings do not seem to injure the shark. The shark cuts up the ray, and swallows the parts, the tail often being included. Thus the stingers get into the stomach of the shark where I have often found them. Eventually these work out through the wall of the stomach and get into the muscles and work toward the head or the tail according as they are pointed. I have found a sting on the back under the skin and another up near the brain.

Why Are Sharks Seemingly Immune to the Sting Ray's Venom? This is the insistent question with which this article must end. And to it there is no sure answer known—at least to the writer.

The ray's sting is a strong, bony, barbed spine (Fig. 1) firmly rooted in the upper median surface of the tail (Fig. 2). Along the center of the underside of the sting is an elevated smooth rib and



After Andre, 1784

FIG. 4. A PIERCED SHARK'S JAW

A STING RAY'S SPINE IS EMBEDDED IN THE JAW OF A TIGER SHARK. LONG BEFORE THE SHARK WAS CAUGHT, THE STING HAD DIVIDED A TOOTH GERM, THUS GIVING RISE TO SIX PAIRS OF HALF-TEETH.

on each side a groove between the rib and the serrate teeth. This may be noted in the spines of Figure 1. Those spines shown in dorsal aspect have a slight groove down the center. Under the root of the spine is the poison gland, and extending backward in the lateral grooves on the ventral surface are poison-filled canals with close-set nipples opening outward near the teeth. When the sting is driven into an object, pressure is exerted on gland, canals, and nipples, and the venom is extruded through the nipples into the lacerated wound caused by the teeth of the spines.

The shark's skin is remarkably thick and tough, being made up of closely

interlaced fibers. It requires a hard-flung harpoon to penetrate the taut skin when a shark has stiffened its body. I have seen a harpoon thrown by a strong and expert harpooner rebound from the humped back of a nurse shark at the Marquesas Atoll in the Florida Keys. Likewise, it requires a sharp stroke for even a keen-pointed sting ray's spine to penetrate the thick and dense skin of a shark, which is often from one-half to three-quarters of an inch thick. And in penetrating it, much—indeed most, if not all—of the poison will be squeezed out and left on the outside of the skin or on the walls of the cut in the skin. Below the skin are the thick body muscles tightly adherent to it. These muscles seem to be much more poorly supplied with fair-sized blood vessels than the leg of a man or any other vertebrate.

But it may be asked, "How about the poison from spines found in the stomachs of sharks?" These had had the poison-gland tissues digested away, and the poison had apparently had no deleterious effect on the sharks, even in the case of the shark with 17 spines found in its stomach. However, it is well known to medical science that certain poisons which are active when injected into the human body are harmless when taken into the digestive tract. And the same is probably true of a poisonous sting and a shark.

From these facts the conclusion may be drawn that the ray's sting probably carries very little poison into the muscle masses underneath the skin of the shark. But the only way to settle the question as to whether this apparent immunity of the shark to the poisonous sting is real is to get a live ray and a live shark. Then one must anesthetize the shark after the technique used at Marineland Aquarium near Saint Augustine, Fla. This done, the skin and body wall of the shark must be laid open to expose a nerve or a blood vessel. Then if a fresh sting is driven into one of these organs, or a solution of the venom in sterile water is injected, one may expect to find whether or not the shark's apparent immunity is real. The same experiment should be done for live rays and for bony fishes. This would surely be an interesting piece of research for some student to take up at a seashore laboratory.

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THE EDUCATIONAL POLICIES COMMISSION BANISHES SCIENCE

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EXCEPT for blind feelings, man's only guide in a complex world is understanding. Today he needs a vast amount of it; and that of the kind that is most reliable.

For several generations the world has been making swift advance in the ways of human living and in the discoveries, inventions, production, and distribution that make modern living possible. With bewildering speed, a simple world has become complex. Affairs that until recently could be managed by simple understandings have become so complicated as to require widened, deepened, and enlarged understandings on the part of everybody.

During the last thirty years of this rapid advance, the world has almost wrecked itself by mismanagement, unnecessary conflicts of purposes and procedures, unnecessary total wars involving the most frightful carnage in the history of the world, and unnecessary confusion of thought, bitterness, and hatred everywhere. As a result, catastrophe has laid its heavy hand on all humankind. The promise of the future is dubious.

The trouble has resulted from man's inability to find the right ways through the complexities of the modern world. It is not that men and women have degenerated; they are as honest, well meaning, and conscientious as ever. Even when wreaking the most terrible havoc, they are aiming at what they think to be commendable objectives. Mankind is sound at heart. People have no desire to destroy themselves or the foundations of their well-being.

The missing ingredient is understanding. The inability of people to see the world as it is, is the source of all their woes. And this disability is not due to native inability to understand. What men create they can, if they try, bring themselves to understand well enough to manage.

Every person, man and woman, needs the best wisdom that can be had. Since everything depends on rightness of guidance, they need the kind that gives the greatest assurance of rightness. And the best knowledge, the most reliable, the only kind that is assured and genuine, is that supported by the most carefully assembled evidence. That is *science.* The science of a thing is the best understanding of that thing that the human race to date has been able to arrive at. The science may be complete or incomplete. It may be entirely, or only partially, established. When fully established, its guidance is wholly trustworthy. Where yet incomplete or only partially established, it is still man's best understanding and therefore his best and safest guidance.

The world is not being wrecked by lack of understanding in the specialized vocations. They have science and they are rigorously obedient to that science. As a consequence, the achievement of rightness and success in the world's work is the most marvelous thing that mankind has yet accomplished. The amazing success of the specializations in finding and holding to rightness is our best proof of the power of science to guide mankind aright.

But a democracy is not operated by

the specialists nor by the wisdom of their specialties. It is managed by laymen, by all men and women, as directed by laymen's understanding. If science is to be the director of this general social management, it must be the science that is known, not by specialists, but by laymen.

The successes of the specialists have been so spectacular, our attention has been so fully focused upon them, that we have mostly overlooked the fact that the world is basically a world of laymen, operated by laymen, for the lifelong well-being of laymen. The work of the specialties is but service to laymen. A person is a specialist serving the general society for some 40 hours a week; but he is a layman, moving in the currents of general human living for some 128 hours each week. It is during this longer period of layman's activity that he is concerned with managing those more general social arrangements and procedures on which the well-being of the world depends. For his guidance during this longer period each week, he needs the greatest possible amount and the best possible quality of layman's understanding; and this is properly called *layman's science* to distinguish it from *specialist's science*.

The two kinds of science are equally sound. They differ greatly, however, in the degree of generality and in the accuracy of the details. In both kinds there are the same fundamentals; but layman's science cannot go far beyond the basic principles, whereas specialist's science goes as far as possible into everything. The specialists are the explorers who discover the science for the use of both groups. They use all of it; the laymen, only the larger fundamentals.

Since laymen are the rulers, they should be equipped with the wisdom needed by rulers. The basic task of the school, then, is to bring all normal men and women to fullness of understanding of the world which it is their combined responsibility rightly to manage. Layman's science, then, in itself and in its applications is the central and chief concern of the schools prior to the level of specialization.

This science should give men and women a sufficient understanding of all portions and phases of reality with which they are concerned, and about which they are called upon to do straight thinking. This is obviously a large order. The interdependencies of things are so great that properly to see any portion of reality one must see and understand the fundamentals of the whole of it.

We must go a little into detail. To see the world of today the layman must see its foundations in the structures and operations of the scores of kinds of atoms with their inherent forces; in the chemical structures and substances with the manifestations that attend their combinations; and he must have a full view of the further matters in the area that we call physics. He must see biological life as it has grown up, as it continues to proliferate in its endless creation, and as it operates in its millions of forms. He must see the more specific structures, functions, ways, and doings of the biological species called man—his body, its structures and functions, the propulsions that drive it, the vision that guides it, and those special biological arrangements, adjustments, and functions that we call economic life, political life, and ethical performance.

We say the layman *must* see these things. We use the term advisedly. If man is to succeed in his efforts to achieve the kind of world for which he hopes and which seems, after thousands of years of heartbreaking failure, to be at last almost within his grasp, then laymen *must* have for their guidance the kind of true and stabilized vision that

science alone can give them. If they are to succeed, there is no alternative. To make the atom bomb was a very simple thing as compared with making a humanized world of the kind that humanity wants; but without science, not in a million years could anybody have ever created that bomb. Even more certainly, without the use of science as guide to laymen, as well as to specialists, not in a million years will mankind bring forth and maintain a worthy social order. Beyond every other layman's need, science is a *must*.

All of the matters enumerated, from protons to the finest elements in the spirit of man, are part of the substance and operations of one integral universe. They are so intimately and inseparably interrelated that it is impossible to understand any of them sufficiently except as one has a sound understanding of the fundamentals of all. Each normal-minded man and woman needs to see the basic realities portrayed by chemistry, physics, geology, geography, physiography, meteorology, astronomy, biology, botany, zoology, human biology, psychology, sociology, economics, political science, and ethical science.

Our question at this point is not, Can so many sciences be taught to all normal-minded men and women? It is rather, What range of understanding do laymen *need* in order to do the straight thinking that will enable them rightly to manage their affairs of every kind in the world as it is? It can be proved that they are vitally concerned with matters in all of those areas of reality; and that they can rightly think, plan, and deal with them only as they have a layman's understanding of them. It follows that they should come to understand them as well as they can. That is all that can be expected. Whatever is done must be within the limits of the possible and practicable.

The question of what sciences laymen should be prepared to use in their daily thinking is almost impossibly confused by two things: (1) the conception that the only genuine and legitimate science is specialist's science; and (2) the usual total obliviousness of the nature, legitimacy, and imperative need of layman's science. The sneers of specialized scientists for layman's science has long been, and is yet, a withering influence. For high schools and junior colleges, they have insisted on specialist's physics or nothing, specialist's chemistry or nothing, specialist's economics or nothing, specialist's everything or nothing. The result has been increasingly, for most sciences and for most pupils, nothing. Insistence on specialist's science before the time is ripe for specialization has not only prevented the layman's science that is so sorely needed, but it has been defeating the specialist's own purposes. It has been driving science out of the schools. Had they been fostering layman's science to the full during the years of schooling prior to specialization, they would have been laying in the whole population the broad and solid foundations needed for the further refinements of the specialist. The latter's intellectual intolerance has been, and is, calamitous both to laymen and to his own supremely important work.

Understanding of things is merely a matter of seeing them—with the eyes and with what lies back of the eyes. Science is nothing more than an adequate seeing of the realities. It is in the power of laymen to see them. They can see position, form, amounts, qualities, relations, functions, behavior, forces, structures, values, genesis, and the nature and operation of the parts and subparts. Their seeing begins in infancy and is a widening and deepening thing through the years of childhood. During those early years, a wide observation and experience can and should provide sound beginnings of understanding. But it is

during the mental efflorescence of youth that the major expansion and deepening of understanding can be expected. It is from the age of fifteen to twenty or so, the high school and junior college period, that the full intellectual luxuriation of each youth should carry him through all the inviting avenues of what the well-awakened scientist knows to be a bewilderingly rich and diversified world.

To see the world as it is, one must go on his intellectual travels over and through that world. To see its various intellectual areas, he must find them all and travel back and forth and up and down through them all, repetitiously seeing in the concrete from different angles and under different circumstances the things that make them up. He must move among and observe the realities as a traveler in a new and magnificent region searches out and views every interesting feature.

If a traveler in a strange country is fully alive, and if he is luxuriating in all the opportunities that the region has to offer, he visits places again and again, enjoying them ever more deeply from the repeated experiences of seeing them under new and different angles of approach. Thus, through a combination of repetitiousness and variety, he matures his understanding and appreciation of everything. And just so it is with the youthful intellectual traveler in this wilderness of a world with its countless vistas of always marvelous and mysterious realities. He finds his intellectual life in a continuity of visiting over and over again all sorts of things in all sorts of ways in all portions of it. In the intellectual world, understanding is matured by a long-continuing repetitiousness in the variety that keeps it always interesting. And the same experience matures the appreciations that give it vigor and drive.

Is the hungry-minded intellectual explorer to memorize the facts, as of a textbook, as he goes along? Let us ask, Does the alert-minded traveler in a new and thrilling region ever stop to "memorize" anything? He does *not*. His seeing has the vividness that constitutes its own memorization. The impressions are burned into his consciousness so deeply and indelibly that he cannot forget them. His memories abide as a vital part of his being. If a traveler has to stop to memorize what he sees, his experiences are so pale and lifeless as not to be worth while.

And so it is with the youthful intellectual traveler through those vistas of reality that have been opened up by the explorations and discoveries of the clear-eyed men of science. If he sees the world widely, deeply, and truly, then he must see it with that vividness of intellectual experience that is the normal mental reaction to the marvels and miracles of a majestic world. If he is moving under full intellectual steam, he does not stop to memorize anything; his experiences are so vivid that they automatically become part of the very texture of his being. As he sees things again and again from countless angles, in countless relationships, in their various manifestations and operations, he matures a sound and unforgettable understanding of them.

When in a former paragraph we said that every normal person needs a layman's understanding of the areas of reality covered by a dozen sciences, we did not mean that he is to "study" and "master" those many sciences in their specialist's forms and in the usual futile academic way. To memorize the verbalities of textbooks of the usual kind is like sitting down in a dim room and memorizing Baedeker as a substitute for going on one's travels. It is both distasteful and worse than useless. A sound understanding of the world is not

acquired in that passively absorptive way.

In its relations to science, the school has two major functions: (1) to guide the growth of sound and proved understanding, as such, as it operates in all its applied forms; and (2) to perform the professional functions along with individuals, families, and community in keeping science the guide in the apprenticeship activities of youth in physical living, health care, family life, community life, association, citizenship, vocation, recreations, amateur arts, religion, emotional living, and intellectual living.

High schools and junior colleges have been performing neither of these two functions. They have not made the science vision of reality—physical, biological, mental, economic, political, ethical—the center and basic substance of their intellectual program. Their present plans do not lie in that direction. Quite the contrary—for layman's education they plan to abandon and to banish science. Let us present evidence of the drift.

The educators of the nation are banded together into two vast and powerful professional groups, the National Education Association and the American Association of School Administrators. In combination, these two associations have named a single Educational Policies Commission to determine the basic policies and plans for American education. This Commission is the voice of authority within the profession.

As the war showed signs of a new truce and a lull in the consuming holocaust, the Educational Policies Commission attempted to discharge its grave responsibility by announcing revised and improved educational policies and plans. After two years spent in assembling its best thought, it presented its conclusions for high school and junior college in *The Education of All American Youth*.

Since this volume voices the wisdom of the specialty for the educational profession, since this wisdom can emanate only from educational science, and since layman's science is the only kind of understanding that is good enough for laymen in an imperiled world, naturally we expect this document to make science the central intellectual responsibility of the school. What we find, however, quite unexpectedly, is that *science of every adequate sort is practically banished from the curriculum recommended for layman's education*.

Let a student take all the layman's science recommended specifically or by implication for high school and junior college, and he will not acquire a well-rounded and well-grounded understanding of the area covered by any one of the sciences, much less of the entire area of human concern.

The document refers casually in a few places to the use of science by students in guiding their efforts in such matters as agriculture, home economics, and health care. It is not made clear how they acquire that science originally; but one gets the impression that it is learned as unrelated fragments in the situations where it is applied. But one cannot learn the broad area of reality covered by a science in that scrappy manner.

The volume recommends that "science" be accorded one-sixth of the program for a year in grade X at age fifteen. But the Commission does not specify the study of the actual substance of any one of the sciences nor of any combination of them. This small part of one year is to be devoted to six things:

> (1) an examination of the scientific techniques used by research scientists in their explorations out on the frontiers of the sciences that are yet unknown even in their fundamentals to the pupils, who therefore are yet wholly unprepared to appreciate the subtleties of the research techniques; (2) noting how the application of portions of sciences yet unknown to the pupils have promoted human advance; (3) the

> biographies of great scientists, with special attention to the techniques that they employed in making certain spectacular discoveries in areas that are yet mostly unknown to the pupils; (4) reproducing in the laboratory a few samples of the epoch-making researches of scientists in fields yet unknown to the pupils; (5) impressing upon students, mostly by talk, that "we live in a world of natural laws, of orderly cause and effect, not a world of chance or arbitrary action"; (6) making children at the immature age of fifteen, and in one-sixth of the school time for a year, "familiar with certain fundamental principles and facts from the sciences, which, when taken together, give him a sound view of the nature of the world in which he lives."

There is not a word said about devoting any portion of the year to developing an understanding of the substance of any one of the sciences.

These things are to be done with a curriculum that is largely made by the fifteen-year-old pupils themselves, thereby forcing the teachers much of the time to superficial verbal improvisation in dealing with it. It is to be so managed that each pupil travels at his own gait, fast or slow, according to his own nature, no two of them traveling together. The pupil is to know the values of science without a prior knowledge of its substance. He is to appreciate and understand subtle scientific techniques used in remote regions of difficult research where at his age he cannot possibly go. He is to be vitally interested in numerous things without having had the experiences that alone can awaken those interests. A few fragmentary facts and principles are "to give him a sound view of the nature of the world in which he lives." These wondrous results are to be accomplished mostly by talk for an hour a day for a year at an age when he is still seven years short of the full normal expansion of his mental powers. And it is all to be done without systematic attention to any one of the major areas of layman's science, whether physical, biological, or human. It makes one wonder what he is to do with his head during the next six years.

The plan is a fantasy. It is startling in its disregard of the realities. As a matter of fact, as we have explained elsewhere, the whole document is a piece of utopian fiction, built on the plan of Bellamy's *Looking Backward,* in which reality and propagandistic imagination are subtly interwoven into a plan that is made to work beautifully as a dream, but which has about the same relation to the actual realities that Walt Disney's creations have to the animal world.

For a staggering world and a crumbling civilization, straight and honest thinking by men and women offers the only hope. Thought of that type is possible only to persons whose understandings are shaped by, and well furnished with, layman's science in its several areas. It is imperative, then, that science be the foundation and the framework of all intellectual education for that sound and honest thinking that alone can operate a complex and difficult world. It is doubly imperative that the education that produces this result be grounded in, and guided by, sane and straightforward educational science. For the purpose, this science should be organized and formulated in such a clear and direct way that everybody concerned can understand it.

In the face of such clear facts, it is nothing less than monstrous to find the organized sciences of all sorts practically excluded from the curriculum by the distinguished leaders of professional policies; and to find that instead of science as a guide to educators they give forth in this document a modernistic artist's picture of how education operates in a fictional world with the impossible perfection that can be put into fiction. If this is the best that education can do by way of organizing its guidance, then the race between education and catastrophe is already lost.

The omission of the physical and biological sciences is only a part of the Commission's failure. The program equally omits the development of an understanding of man as the world's most notable biological species, of his emotions as biological drives, of his understanding as biological guidance, and of his economic, political, humanitarian, and ethical procedures as adjustments in a stern and exacting world of never-ending struggle for an elusive security. These areas of human life are wide and complicated. Every man and woman needs to see their fundamentals with the greatest possible clearness. They need the best practicable layman's understanding of all the major human sciences. And yet the Commission does not so much as mention a single one of them, much less state their indispensability or give them adequate place in the program. They are omitted utterly. The Commission clearly rejects the principle that in a world of greatly mismanaged human affairs, only the best possible understanding, namely, science, can provide the only guidance that is good enough. To the Commission, the human sciences are not a *must*. They are not even important. Their value, if any, is so minor that they need not even be mentioned.

The Commission recognizes that human affairs are to be guided; but the guidance for which its plan would prepare is not that of science, but rather that of the shrewdness of the opportunism that is called political action. The direction of human affairs is not to be determined by that understanding that alone can find the right ways, but by the force, actuated by self-interest, that can be exerted by superior numbers, without regard to, or even knowing, what is right and just. This retreat from rationality as human guidance back to self-interest, force, and strife, brought to high operating efficiency by education, as the mode of managing human affairs would be the abandonment of the very basis of civilization.

The document recommends American history with artful emphasis, but says that it should be refocused and rewritten. It is careful not to say how it should be rewritten; but the general tenor of the volume indicates that American history is to be an instrument for strengthening the powers of persons for the strife of political action. If this is misinterpretation, it results from studied vagueness.

The Commission recommends that one-fifth of the entire high school and junior college be devoted to "Education for Civic Competence." This would be a superlative recommendation if the term "civic competence" were intended to mean wisdom and power in finding and holding to the ways, sanctioned by human science, for achieving right and justice to all. But by "competence," the Commission appears to mean power in the techniques of social conflict. In no uncertain terms, it voices the need of social understanding; but it does not even remotely mean that best understanding that we call science. If that were the meaning, it would be stated in definite terms.

The teaching profession is so much accustomed to weird and irresponsible pronouncements that it will look upon this latest piece of propagandistic fiction as but another example of the profession's habitual and expected make-believe. This negative attitude toward even its supposedly most authoritative literature gives it a kind of protective immunity. Educators will give this document such casual and momentary attention that its influence for harm will not be great. But this is only one of a never-ending series of pronouncements. Each affects the next in line, and also the professional consciousness, in some slight degree. There is thus accumulation of error and of tolerance

for error until in time it is very great, and the profession is unsuspectingly fully misled.

The profession has already been led so far astray that it scarcely sees anything amiss in this incredibly fantastic volume. It accepts it favorably for a moment as a matter of course and then goes on to the next in which there is a slight but imperceptible further turn toward the propagandist's goals. In this way, propaganda subtly and invisibly achieves its unannounced purposes. The present volume is a superb example of the power and skill with which this can be done.

A profession ruled by science, such as medicine or engineering, is not of this type. It goes forward today with breathtaking speed, but it follows the straight road laid down for it by its own technical science. As it changes its course with new discoveries, its deviations are always toward the more perfected truth and never away from it. It views the ways of propaganda as the ways of charlatanry. And such adult professions never use irresponsible utopian fiction as their crafty method of giving forth their science to their members. They would view it as a method of incredible juvenility, a mere toying with the matters of life and death. They know that the responsible adult mind does not operate in that way.

TO THE NEW PHYSICS

Now we who thought we lived on firmest earth
Find that we live with song, nothing but song:
From the ninth interval that is our birth
To the heart's full chant, to music we belong:
Close harmony proceeds where no throats are;
Not only trees are tongued, but mould and dew,
And music issues from the morning star
As surely now as when the heavens were new.

A flower unfolded is a mouth achieved,
Its scent a song; the many-throated rain
Marks the crescendo of a psalm that lived
In humming clouds, muted in mist again;
While the incessant spirals of our prayers
Build for the high heavens their only stairs.

A. E. JOHNSON

SCIENCE AND NATIONAL POLICY*

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THAT our national security, health, and prosperity depend to a great extent on science for their maintenance and their future improvement, no informed person would deny. The great drafts which we are making upon our natural resources, the demands of labor for a better standard of living, the requirements of industry for markets and profits, and international competition all pose problems among whose essential requirements for long term solution are vigorous advance of scientific knowledge and equally vigorous application of this knowledge for useful purposes.

The subject "Science and National Policy" therefore deals with one of our important national problems. I can only hope to paint the picture with a few broad strokes and to discuss certain specific measures now before Congress on which wise action is needed promptly.

Historically, our federal government has concerned itself with science in two directions: first, through its permanent scientific bureaus; and, second, through its calls for temporary help in times of emergency.

Within the framework of the federal government there are about forty bureaus of more or less scientific character. Generally speaking, these are service bureaus which employ scientific methods to supply the public with types of information or help which private enterprise is not well fitted to provide. The Bureau of Standards, the Weather Bureau, the Geological Survey, the Bureau of Mines, and various bureaus in the Department of Agriculture are examples. Their services to the public are essential and should be maintained in a high state of efficiency.

In times of great emergency the federal government has called upon the creative scientists of the country generally for help, and this help has always been given wholeheartedly, to the very great advantage of the country. In 1863, at the time of the Civil War, the National Academy of Sciences was established by Act of Congress and approved by President Lincoln. This Act specified that "the Academy shall, whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art. . . ."

Again, when war clouds hung low over the world in 1916, President Wilson by executive order requested the National Academy of Sciences to establish the National Research Council as a measure of national preparedness.

Again in 1940, when threat of war hovered on our horizon, President Roosevelt established the National Defense Research Committee which, one year later, was enlarged by the establishment of the Office of Scientific Research and Development. And during the darkest days of this World War II, when Japan had cut our lifelines to natural rubber, the President appointed the Rubber Survey Committee which organized a group of scientists, engineers, and businessmen under the statesmanlike leadership of Bernard M. Baruch to establish a program for meeting this technological crisis.

In every one of these cases the scientists of the country responded immediately to render national service with

* An address delivered April 25, 1946, before the American Newspaper Publishers Association, New York, N. Y.

outstanding effectiveness. The recent success of the rubber program and the wartime achievements of the scientists in developing new medicines or new weapons, culminating with the atomic bomb, are too freshly in mind to require further comment. They shortened the war, saved billions of dollars and millions of lives, and were one of the essential elements in victory.

One thing which does require comment, however, is this peculiar fact: Why has it been only in times of desperate emergency that the government has called upon the scientists of the country in any significant way to perform service, and why is it only at these times that the government has provided the funds necessary to implement any scientific programs of substantial character?

President Roosevelt had this question constructively in mind when he wrote in November 1944 to Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, requesting recommendations for a program to aid research activities by public and private organizations, to continue the war of science against disease, and to discover and develop scientific talent in American youth, so that the continuing future of scientific research in this country may be assured on a level comparable to what has been done during the war. Dr. Bush had this in mind in his reply to the President when he said:

> New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war, we can create a fuller and more fruitful employment, and a fuller and more fruitful life.

But let me approach this matter from another angle.

I fear that the American public generally has a false sense of security through a naive belief in the superiority of American science over that in other countries. This belief undoubtedly comes about naturally from the fact that American industry has shown unparalleled initiative, drive, and skill in pouncing upon the practical applications which can be built upon scientific discoveries made any place in the world and turning out manufactured products of superior quality and in unequalled quantities. American advertising, however, is not accustomed to admit that such and such of its developments have sprung from a scientific discovery in Holland, or in Russia, or in Germany. The actual fact is that American science is strong and its scientists are able, but America has no monopoly, nor does it have even a majority position, in the record of scientific discovery.

Along this line I quote three paragraphs from the first issue of the new McGraw-Hill publication *Science Illustrated.*

> But our wartime victories in applied science were based largely on basic European research. The fission of uranium was first developed in Germany. Bloodbanks originated in the Soviet Union. The discovery of penicillin earned Nobel prizes for three British subjects.
>
> It is a matter of prime concern that our own basic research has lagged so far behind our industrial capacity to absorb technological developments. The extent to which our industrial machine has lived off foreign basic knowledge is shown by the distribution of Nobel prizes. [The article then goes on to show that only 18 out of the total of 131 Nobel prizes which have been awarded in physics, chemistry, medicine, and physiology, have gone to scientists of the U. S.]
>
> This situation is likely to grow worse unless definite steps are taken soon. Available figures show that only one-seventh of the national research budget was going for basic research before the war. Now as a result of war-interrupted educations of thousands of youth, the nation faces a deficit of scientifically trained personnel.

Actually, until about the time of the first World War, the United States was distinctly a third- or fourth-rate nation so far as science, either in scholarship or in creative research, was concerned.

Since about 1920 the United States has advanced with great rapidity, and by the beginning of World War II it had achieved a position roughly abreast of the other more advanced nations. No informed scientist, however, can say that it has ever achieved a superior position.

In my judgment the rapid advance of creative science in America since about 1920 was principally due to two causes. One of these was the increased public awareness of the value and power of science, arising from the demonstrations of its effectiveness which were made during World War I. American chemical industry, for instance, practically dates from this period. More able young men were drawn into scientific careers, and there was greater public support of scientific research.

The other great influence, in my judgment, was the program of postdoctoral National Research fellowships, which were financed by the Rockefeller Foundation and administered by the National Research Council. The Rockefeller Foundation realized that the war had interrupted the education of scientists, and that there was a deficit to be made up. Furthermore, this Foundation has always been intensely interested in the advancement of medical knowledge and art, and it had the foresight to realize that the most fundamental advances in medicine in the long-term future were likely to be based upon new discoveries in physics, chemistry, and biology. As a result, a majority of the top scientists in America at the present time and a majority of those who took the leading roles in our recent scientific war effort were scientists who had been given this opportunity for special advanced experience in research by these National Research fellowships.

From these facts we can certainly learn a lesson for our guidance today!

Now let me lead up to the subject of national policy by still a third route, the financial one. If the scientific experience in this war proved any one thing, it proved that the teamwork of groups of competent scientists, supported by adequate technical assistance and all the equipment which they needed, could accomplish more than even the scientists themselves had dared dream. But such research programs cost money.

Industry can and will carry part of the load. But its interests are largely limited to the business possibilities of practical applications. For this and several other convincing reasons, we must, as in the past, look principally to the educational institutions to produce new scientific knowledge.

But in the past fifteen years or so the income from endowment funds of these institutions has seriously shrunk, and future prospects for large gifts and the growth of a new generation of great philanthropists are not promising. I need not expand upon this sad story.

We seem, therefore, to be faced with a very definite dilemma. The value of a vigorous program in creative science is clear. National policy requires it in the public interest. The institutions where the work can best be carried on cannot from private sources finance the whole load. This is true in all scientific fields and, above all, in the new field of nuclear science and atomic energy. Apparently the only possible answer to this dilemma is an adequate program of federal support of fundamental research.

It is such a program that ex-President Hoover sought unsuccessfully to finance by private gifts through the National Academy of Sciences while he was Secretary of Commerce. It is the same program, financed with federal funds, which was advocated by President Roosevelt, and now by President Truman, and for which bills have been introduced by forward-looking members of the Congress. It is a plan which has been followed for some years with considerable success in

Great Britain. It is a plan which is being followed on an enormous scale in the Soviet Union, where, for example, there was a strongly supported institute of nuclear science long before our own federal government gave a thought to atomic energy.

The time seems ripe for favorable action on the two great scientific projects now under consideration by our Congress: the establishment of a National Science Foundation and the establishment of an Atomic Energy Commission, both provided with adequate funds for investment in the security and prosperity of the United States. Having in mind the factors which I have already outlined and knowing rather well the conditions essential to efficient and successful scientific research (which differ in some important respects from running a railroad, or a factory, or a governmental bureau), I urge that we lend our full support to the following program of national policy in science:

1. Pass legislation to establish the National Science Foundation and to establish the Atomic Energy Commission.

2. See to it that this legislation is wisely drafted, but do not let desire for perfection unduly delay its passage. Minor defects can be corrected later as experience accumulates.

3. To the greatest extent possible, free the legislation from specific controls or restrictions; define objectives rather than specify rules for achieving them.

4. Place the control of the program in the hands of men who are competent, fair minded, concerned with its various major aspects, and experienced in the ways of science; and trust such men as patriotic citizens to handle the program in the public interest.

This scientific program is a matter of general interest to every element of the public. There is no profession or class of citizen who will not benefit from it. There is nothing in it of a political character. Are we not therefore justified in expecting that forward-looking statesmanship will enact the legislation, that patriotic citizenship will administer it wisely, and that the oncoming generations of scientists will carry it forward with high success to the benefit of all?

ON THE MATHEMATICS OF COMMITTEES, BOARDS, AND PANELS*

By BRUCE S. OLD
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THE present is considered to be a most appropriate time to study analytically, with a view toward improving, the efficiency of functioning of committees, boards, and panels in general. Two reasons supporting this stand are:

(1) The prosecution of scientific work during World War II was largely in the hands of committees, boards, and panels (*miserabile horribileque dictu!*).

(2) The security regulations still in operation, such as the Espionage Act, prevent the publishing of interesting treatises and force technical journals to accept almost anything.

The three items under consideration can be defined briefly in the following manner:

(1) *Committee.* A body of persons appointed to consider, investigate, or take action upon, and usually to report concerning some matter.

(2) *Board.* A council convened for business. (There is absolutely no authenticity to the definition "long, narrow, and wooden" sometimes applied.)

(3) *Panel.* A list or group of persons appointed for some services.

It is immediately apparent from these definitions that committees, boards, and panels are similar in that all are groups of one or more persons formed *to accomplish work.* Thus they will be treated simultaneously in this paper.

There are numerous methods of expressing mathematically the objective of committees, boards, and panels: namely, to perform work. The most commonly applied formulae are the following:

(1) The utilization of the familiar time, force, and distance relationship where the object is to maximize the expression

$$\text{ComBulPac} = \frac{fd}{t}$$

in which ComBulPac = code name for power output of committees, boards, and panels, f = force, d = distance, and t = time.

This equation was the origin in 1812 of the expression "a powerful committee."

(2) A second and very appropriate method is the use of the gas law as a basis for the work expression. Here the attempt is made to maximize final minus initial gas volume:

$$\text{ComBulPac} = \int_{v_1}^{v_2} p\,dv$$

in which p = pressure and v = volume.

It is held by experts that Gay-Lussac first evolved from this relationship the phrase "a high-pressure committee." On the other hand, there is no foundation for the rumor that the current slang phrase, "the committee is cooking with gas," was derived from this equation.

(3) Another method which is very useful under certain circumstances is

$$\text{ComBulPac} = Le$$

in which $L = Fr$, F = force, r = radius, and e = angle.

This, the reader will recognize, is the well-known "revolving committee."

* The able assistance of the members of the old staff of the Office of the Coordinator of Research and Development and the Office of Research and Inventions of the Navy Department and the assistance in critical review by the Applied Mathematics Panel of the NDRC are greatly appreciated.

Data were generously supplied from many sources. These, naturally, are still confidential so that no actual numbers could be used in this paper.

(4) A fourth method of setting down the work expression is becoming very common since the importance of air power has been realized:

$$\text{ComBulPac} = M(V) - C_D\frac{\rho A V^2}{2}$$

in which M = mass flow, V = velocity, C_D = drag coefficient, ρ = density, and A = area.

Recognizable immediately, here is the "committee with drag." (Drag is high for certain simple bodies.)

(5) A fifth method of calculating output has been evolved during World War II. This is to express the output for the widely used "joint" committee:

$$M = \frac{\gamma \sum Y^2}{y}$$

in which M = resistance to moment of a group of rivets in a riveted joint, γ = total allowable stress per rivet (or committee member), $\sum Y^2$ = sum of squares of distances from center of gravity of the group of rivets, and y = distance of outermost rivet from center of gravity of the group.

The reader will note that, although elastic bending under stress of great magnitude occurs, no work is accomplished by the joint committee.

In order to determine which of the five equations best expressed the output obtained, the performance since December 1941 of a large number of committees was analyzed. Very poor correlations were found between the actual and theoretical calculated work outputs. These results are plotted in Figure 1 for all five methods of calculation.

This poor correlation showing the actual output of wise decisions, good reports, and constructive accomplishments per year, always far below theoretical, led to the decision that a much more thorough analysis than had been made heretofore would have to be undertaken. The importance of this study to the war effort was such that an overriding priority was assigned. (By a fortunate error, the file clerk placed this problem on the top of the growing pile of overriding priority projects so that it took an over-overriding precedence and was completed only seven months behind schedule.)

Analysis. The most logical mathematical approach to the problem of calculating accurately the output of committees appeared to be the application of the method of multiple correlation. This tedious procedure was therefore used. Certain machines, such as the one at Harvard College, were of invaluable assistance in carrying out the calculations.

It was decided that the work output must be such that

$$W_a = E_2 W_t$$

where W_a = actual work, W_t = theoretical work, and E_2 = actual efficiency of the committee.

Since it was believed that W_t could be calculated quite accurately, it became obvious that a study of the factors affecting the efficiency of operation of committees, boards, and panels leading toward an accurate calculation of the efficiency, E_2, was the key to the problem.

Therefore, as a first step an equation was written in the following form:

$$E_1 = f(n)\, f(i)\, f(c)\, f(hs)\, f(t)\, E \quad (1)$$

in which E = theoretical committee efficiency, E_1 = calculated committee effi-

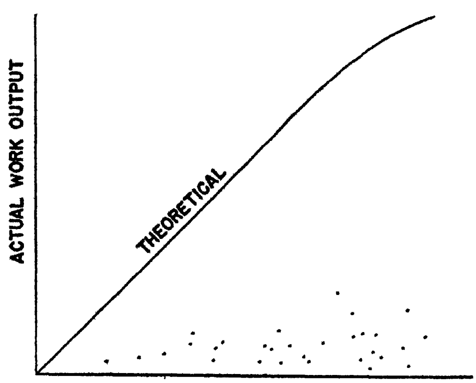

FIG. 1. WORK OF COMMITTEES

ciency, $f(n)$ = function of number of committee members, $f(i)$ = function of intelligence of committee members, $f(c)$ = function of type of committee chairman, $f(hs)$ = function of type of hecklers and saboteurs on committee, and $f(m)$ = function of the miscellaneous element; and where the calculated committee efficiency is expressed as a function of various parameters times the theoretical efficiency. The object is to arrive at the proper values of the various parameters so that

$$E_1 = E_2$$

where E_1 is the calculated and E_2 the actual efficiency.

A thorough study of the parameters in equation (1) will now be undertaken.

Many examples show that the number of men on a committee, $f(n)$, affects very materially the work accomplished. These data are plotted in Figure 2. It is apparent that it is best in many cases to have the membership limited to one, and membership of over five is usually fatal.

One striking thing to note about Figure 2 is the large scatter of points for any one value of the number of committee members. This was interpreted to mean that other parameters were affecting the data, such as the intelligence, etc., of the individual members. That this is actually the case will now be shown.

A large number of observations have been made of the effect on output of the

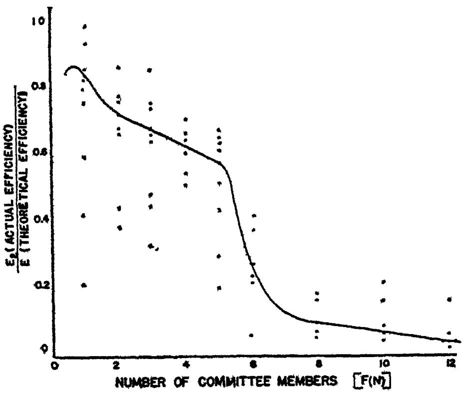

FIG. 2. EFFICIENCY VS. NUMBERS

intelligence, $f(i)$, of individual committee members. This matter of abilities of personnel on committees can usually be reduced to the following simple terms of division:

(1) Working-level personnel who know the details of the subject under consideration.

(2) Policy-level personnel who know no details of the subject under consideration.

Thus in forming a committee, one is confronted with the decision as to whether he wishes the membership to be composed of working- or policy-level personnel. The war has presented a unique opportunity for arriving at a proper answer to this question. It so happens that the rank of a military man is directly related to the degree to which he is a policy man, thus allowing an absolute measure to be applied. Pursuing this promising lead, a remarkably fine set of data was collected, thus allowing the establishment, as follows, of perhaps the most fundamental law discovered in this paper:

$$I = \frac{E}{R} \quad \text{(Old's Law)}$$

in which I = intelligence in any given subject, R = rank of individual, and E = a constant of very small magnitude of the order of $1/c$, where c is the velocity of light. This indicates that E has the dimensions of a wave "slowness."

As can readily be seen from Figure 3, there is little deviation from the law except at the extremities. (In this regard it maintains its similarity to Ohm's Law, $I = E/R$.) It follows that it is a simple matter to deduce the fact that if one desires to form a committee with high efficiency of work output, it is essential to select working-level personnel. Data supporting this statement are plotted in Figure 4. As would be expected, there are individual exceptions which appear as points off the curve, and those will now be analyzed.

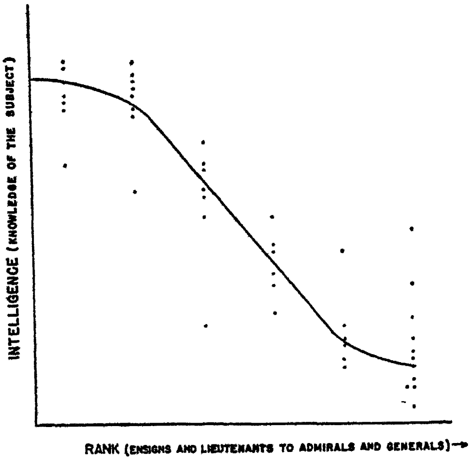

FIG. 3. INTELLIGENCE VS. RANK

One factor which affects strongly the ability of even an intelligent committee to do useful work is the capability of the chairman of the committee ($f(c)$). Let us type the characteristics of committee chairmen in the following manner:

(A) A really capable man who knows the subject, has well-prepared agenda distributed before the meeting, skillfully keeps people on the subject (but not to the extent that he does not allow both sides of questions to be thoroughly exposed), requires that action be taken on agreements reached, follows up on such actions, makes efficient use of the method of task assignment to subcommittees, provides for periodic needling of the committee by outside experts, requires written comment on reports circulated to members, insists on a minimum of six committee meetings per year, and employs an efficient secretariat.

(B) A man similar to Type A in every respect except that he is too nice a fellow to interrupt ramblers, particularly if they happen to occupy a higher position or are older than he.

(C) The man who is one of the leaders in the field under consideration but who uses the committee merely as an instrument to second his ideas. In cases where questionable ideas have to be forced through, he lines up his votes beforehand or rudely interrupts all opposition.

(D) The chairman who is obviously too important for the committee. He sends a deputy to run the meetings with instructions to hold off on any really important decisions until he can find time to attend and whip things into shape.

(E) The chairman who opens the meeting by frowning slightly and saying: "Now, er, ah, let's see. Heh, hrrmphh, ah. Who called this meeting? I mean, what are we here for today?"

The strong effect of the type of chairman, $f(c)$, on the efficiency of a committee is shown in Figure 5.

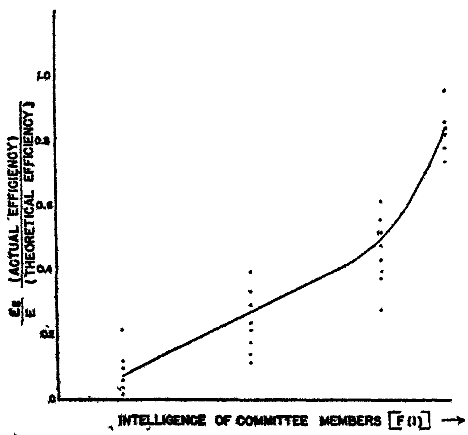

FIG. 4. EFFICIENCY VS. INTELLIGENCE

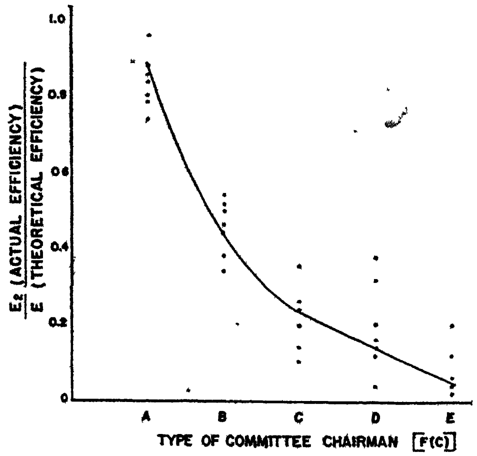

FIG. 5. TYPE OF CHAIRMAN

There are some conditions which can ruin the efficiency of a committee even though it may have intelligent members and a competent chairman. The most serious of these is the heckler-saboteur function, $f(hs)$. The main types of heckler-saboteurs, many of which are well known, are as follows:

(*A*) The normal man. (All *Homo sapiens* have some faults.)

(*B*) The jolly fellow who is always 22 minutes late and then holds up proceedings 7 more minutes telling (off the record) his latest joke. Although he never does any committee work between meetings, he is such a good egg he never fails to get reappointed.

(*C*) The man with an elephantine memory to whom all ideas are old and who can still quote all the reasons used to turn any one of them down 11 or 12 years ago. No chance for viewing anything in a new light is given—the mere fact that he had heard of it before is sufficient reason in his mind to vote against any idea.

(*D*) The man who is against initiating any work, because, since there is a shortage of scientific manpower, any new project undertaken is bound to interfere with the progress of all existing projects (particularly two of his pet programs).

(*E*) The poor fellow sent to represent his boss who has instructed him in such a manner that all he can do is sit there and say, "I don't know," or "I have no authority to speak for my agency."

(*F*) The policy man who is afraid the rest of the committee is trying to take away some of his power and authority. Thus, he views each question not from the standpoint of whether it is the best thing to do, but whether the answer given might possibly be misinterpreted by anyone as permission for someone to infringe upon his cognizant empire.

(*G*) The man who is on the defensive. He suspects the committee has been formed just to change (Note: for the better) his method of doing something. His actions are almost bound to hew to the following pattern:

(1) Announces that his office carefully considered this idea, which is really not basically a new one, about a year ago, and decided to turn it down in favor of the design now in use.

(2) When (1) is attacked successfully, states rather emphatically that this new design is just the idea of some long-haired, impractical professor who doesn't understand the wear and tear on this gear out in operation.

(3) When (2) is successfully countered by the opposition, says proudly that the Fleet has never complained about the present equipment (but fails to say the fellows who should complain are all dead, or too busy, or don't know about the new idea).

(4) When (3) is slipping, reads a policy directive issued by the Chief of Naval Operations in 1924 which makes it somewhat doubtful whether regulations allow informal committees like this cognizance to recommend a change.

(5) When (4) is overruled, says confidently that the training program is so far advanced no design change could be tolerated.

(6) When (5) fails, pulls his ace and shouts that ship deliveries are being held up now because the production schedule on this equipment is way off, and no design change could possibly be accepted even if it were an improvement. After all, there is (or was) a war going on!

(7) If (6) fails and enough rope is given, goes all the way out and openly hangs himself by sneering that of course if you want to make this equipment so perfect the enlisted man using it doesn't even have to exercise any judgment (Note: such as doing double integrations in his head), he won't take the responsi-

> bility for your having ruined the man by making it unnecessary for him to use his skill gained through supertraining.

The effect of the $f(hs)$ factor is plotted in Figure 6. The gain that can be made

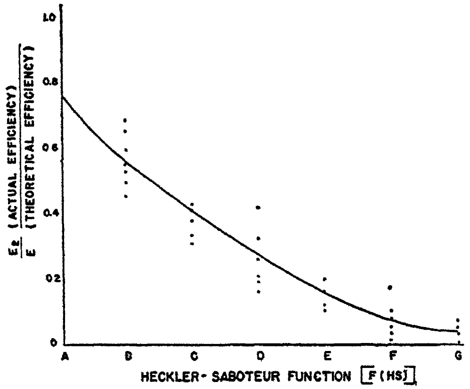

FIG. 6. TYPE OF SABOTEUR

by selecting A type committee members is very apparent.

Finally, there are several factors that can best be termed "miscellaneous" which upon occasion seriously affect committee efficiency. Among these are such things as the temperature of the conference room, the degree of comfort of the meeting chairs, the size of lunch served, the amount of time wasted during the meeting in arranging for train and hotel reservations, and whether a quorum of committee members happened to get together the night before the meeting and settle all the expected controversies of the morrow in the bar. The latter practice is recommended by many competent committee chairmen but requires more research before definite conclusions can be reached.

From the nature of the miscellaneous factor, $f(m)$, it is apparent that this parameter must be estimated for each special case.

Results. Using a slightly modified standard form of multiple correlation calculation to evolve the proper parameters for the several variables, a variance of 0.3 was obtained for correlation between calculated and actual committee efficiencies. Snedecor's test of significance showed this multiple correlation to be almost significant.

Employing corrected calculated efficiencies, the actual (W_a) and calculated (E_2W_t) committee work outputs have been replotted in Figure 7. It will be noted that, while a distinct improvement has been made over the original data plotted in Figure 1, the actual work output of committees is still disappointingly far below theoretical.

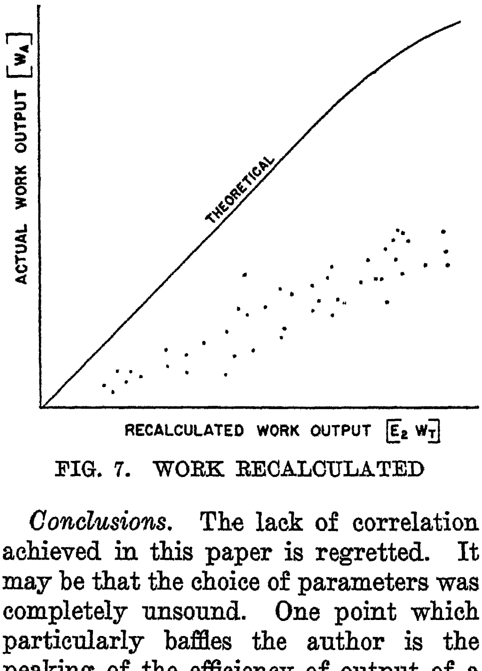

FIG. 7. WORK RECALCULATED

Conclusions. The lack of correlation achieved in this paper is regretted. It may be that the choice of parameters was completely unsound. One point which particularly baffles the author is the peaking of the efficiency of output of a committee versus number of committee members (Figure 2) at seven-tenths of a person. Obviously one must conclude that either further research is required or that people are no damned good.

FREEDOM IS FITNESS

By ARCHIE J. BAHM
DEPARTMENT OF PHILOSOPHY, UNIVERSITY OF DENVER

An individual is free whenever he is able to do what he wants to do. There are as many kinds of unfreedom as there are kinds of things which make it impossible to do what one wants to do. Some of these result from causes outside of self; others result from internal causes. For example, if I wish to climb a tower but lack sufficient energy or desire, then I am unfree to do so.

Feelings of freedom—to be distinguished from real freedom—arise most commonly in connection with awareness of external limitations. To feel self-determined is to feel free. Self-determination arises out of a feeling that the causes of action are internal. Because we conceive ourselves differently at different times, what it takes to make us feel free will likewise differ from time to time. Since the stature of a man depends upon the number and kinds of things with which he feels identified, the amount of freedom he feels will be determined by the number and kinds of causes of his action that seem to be contained within himself. The larger the range of identification, the freer he feels. If only external restraints, or the things to which he feels opposed, cause the feeling of unfreedom, then any shift in feeling from opposition to identification involves a shift in feeling from unfreedom to freedom.

Real freedom, as compared to feelings of freedom, has to do with limitations to action, regardless of whether there is awareness of these limitations. Freedom to be or to do exists only if conditions permit.

For terminological convenience causes conceived as internal are spoken of as "capacities," and those conceived as external as "opportunities." A man is *able* to do only what he has capacity and opportunity to do. Thus "capacities" and "opportunities" together make up "abilities." If real freedom means "being able to do what one wants to do," then ability to do depends upon whether both required capacity and opportunity are present.

Freedom involves fitness, and is measured by the extent to which capacities and opportunities are fitted to each other. It also involves functional efficiency. Two persons, one with great capacity and equally great opportunity and one with small capacity and equally small opportunity are, in a sense, equally free. Concomitant increase in capacity and opportunity makes one freer—quantitatively. Increase in fitness of capacities and opportunities to each other makes one freer—qualitatively.

Although real freedom rests upon relative fitness of opportunities and capacities, regardless of whether there is awareness, freedom may be affected by awareness. Insofar as action cannot take place without awareness, such awareness, or degree of awareness, is a part of capacity. Or, awareness may serve also as opportunity, for where there is no awareness, there is no appreciation of opportunity.

An individual may have abilities of which he is aware, but which he has no desire to use. Insofar as he cannot act without desiring to act, such desire is part of his capacity or opportunity to act. Increasing interest in doing what one is capable of doing actually makes one more free, and increasing indifference to one's abilities decreases freedom.

Conflict of desires affects freedom; and the more intense the conflict, the less freedom. Each opportunity to choose

between desired alternatives presents a conflict of desires, and until a decision is reached a state of unfreedom exists. What relief is felt when an important decision has been reached! It might be supposed that the more choices there are, the more decisions to be made, the more freedom exists. Actually the very opposite is true. "Freedom *from* choice" is as much a kind of real freedom as "freedom *of* choice." Real freedom, then, consists in fitness of capacities, or internally caused abilities, and opportunities, or externally caused abilities.

Feelings of unfreedom always occur when opportunities seem to be limited by external causes, but these change to feelings of freedom whenever feelings of identification with these causes arise. Such changes normally happen automatically without attention to, or awareness of, them. Suggestion and habit play a large part. However, one can deliberately seek such change.

FREEDOM FOR WHAT?

A man alone with nature in the raw
Is free as are the beasts of field and wood
Not one whit more nor less, and life is good
To him alone who knows and keeps its law.

Seek not for freedom in uncultured hordes.
The bonds of custom weave a fearful net
That rigid bounds to innovation set
Nor brook advance where status quo is lord.

The academic voice was scarcely heard
In frontier fights for freedom of the mind.
Defender of the faith and state, it whined
To gain prestige, and in their thoughts concurred.

The grant to him who seeks where truth applies
Is not a right primeval but has grown
From test pragmatic and from value shown.
On this our future social wealth relies.

When counter to the mass a thinker stands
And points to truth, then should his peers defend
By show of worth 'till opposition end,
And reasoned aquiescence raise its hands,

For freedom gains momentum if and where
Directed to some other goal than self
It adds to life stability and health
Removing ignorance and groundless fear.

JOHN G. SINCLAIR, 1945

SCIENCE AS THE COMMON GROUND FOR RELATIONS BETWEEN NATIONS[1]

By M. PIJOAN[2] and F. TROWBRIDGE VOM BAUR[3]

DURING the past twenty years there have been remarkable changes in the relationship of political structures to each other. Political negotiation in the old sense can be considered as outdated when expressed in terms of subtle argument, hidden motives, or in settlement through procrastination. Compromise, somewhat effective as yet, will, in a short period of years, become rarer; political schemes can be seen through, even though "the guarded phrase" results in the maintenance of friendly relations. Today there are no schemes which cannot be understood; what is important is the method at arriving at the truth. President Truman, commenting at San Francisco, stated:

> The world has learned again that nations, like individuals, must know the truth if they would be free—must read and hear the truth, learn and teach the truth. We must set up an effective agency for constant and thorough interchange of thought and ideas. For there lies the road to a better and more tolerant understanding among nations and among peoples.

This statement implies the use of the scientific method and not "impressions gained" or flowery statements of a superficial character. It emphasizes the necessity for a general respect for the truth throughout the world as the foundation for better relations between nations, and in the recognition of truth the role of science and professional people is paramount.

The last war has demonstrated perfectly clearly that diplomacy based on facts is a nation's first line of defense. Only when diplomacy breaks down does war result. Hence the importance of good diplomacy, that is, of maintaining good general relations between nations, can scarcely be overestimated. With the development of atomic energy it seems obvious that if civilization is to survive it can do so only on a basis of maintenance of good relations between nations which will be founded on genuine, not superficial, understanding and respect between their peoples.

The traditional concept of diplomacy has been that of negotiation and personal relationship between two high-ranking officials of separate governments. These two might be close personal friends, yet their governments and peoples might be hostile. Or the two diplomats might not get on well personally, though the feeling between their governments and peoples might otherwise be friendly. Under this traditional concept, much depends upon a single man for good relations with a foreign country. The importance of selecting able men in the Foreign Service of the United States to serve as ambassadors and diplomatic officers and of paying them adequately will be in the future more important than ever, for they have the prime responsibility of maintaining good relations with foreign countries.

We are now faced with the compelling necessity of reaching and maintaining an understanding, a mutual respect and appreciation between the peoples of different nations from which an enlightened public opinion can arise that will tend to prevent a sadistic madman from reaching a position of power in some country,

[1] The opinions and views of this article are those of the authors and not necessarily those of the Navy Department or Office of Inter-American Affairs.

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with the plan and the real chance of destroying the rest of civilization. Such an enlightened public opinion can provide the substantial bulwark for diplomacy which in the future will be indispensable.

Hence today we see the beginning of international relations based on the collection of data pertinent to a case; of peoples calling on peoples for understanding and common action through the efforts of enlightened agents using scientific methods. The essentially simple solution of delegating problems to experts in the subject matter has finally been reached.

A NOTABLE example of the use of experts in adjusting difficulties between two democracies having common aspirations and problems is the recent settlement of the Mexican oil expropriation difficulty. (The following discussion is taken in substance from H. S. Person's *Mexican Oil,* Harper and Bros., 1942.) It should be observed that this effort to settle the Mexican oil problem by referring it to experts whose agreement, if reached, should be definitive as between the two governments was not intended by either government to establish a precedent either in respect of method or of findings. The final item of the agreement between the two governments states specifically that

> nothing contained in this note shall be regarded as a precedent or be invoked by either of the two governments in the settlement between them, of any future difficulty, conflict, controversy or arbitration. The action herein provided for is solely to this case, and motivated solely by the character of the problem itself.

However, as an example it has significance not confined to the two nations that were parties to the settlement.

On March 18, 1938, the Mexican government, for well-known reasons, expropriated the oil properties owned by certain corporations that were nationals of the United States of America. There followed four years of attacks on the Mexican government by the expropriated companies, who demanded that the properties should be restored, and of firm and courteous "diplomatic" exchanges between the two governments involved concerning the indemnities to be paid and the conditions of payment. Eventually these governments made an agreement dated November 19, 1941, to the effect that settlement of the amount of the indemnity should be left to experts, one representing each government; that any agreement reached by them should be final insofar as the two governments were concerned and that if agreement were not reached by April 19, 1942, the matter would automatically be restored to conventional "diplomatic" negotiation.

The expert appointed by Mexico was the undersecretary of the Department of National Economy, an engineer, Manuel J. Zevada. The expert appointed by the United States was Morris L. Cooke, consulting engineer, of Philadelphia. Each of these experts assembled a staff of specialists for the appraisal and other purposes, all leading to the agreement on the amount of the indemnity announced April 17, 1942. This then was an efficient and effective method of arriving at an agreement in a short period of time.

Formally, on the face of the assignment, the problem was one of simple evaluation—of arriving at a value for purpose of indemnification through business-engineering methods of appraisal and by precedents validated, in the United States at least, by decades of court decisions. But in reality the problem was even greater with respect to the value of the oil properties. There is no such thing as an absolute value since there are many relative values, and in context it means as many kinds of value as there may be purposes of valuation. Thus what appears to be a conventional

business-engineering appraisal was complicated by the need of harmony between experts and the ideologies of two nations. There could be no agreement in measurement without harmony. In this respect the scientific common ground was indispensable and was undoubtedly the main factor in achieving harmony and agreement.

The main problem was one of harmonizing two great social forces, one Mexican, the other based on Anglo-Saxon traditions, institutions, and laws. Each had a different origin and development. Settlement of the problem of indemnification for expropriated oil properties became a joint experience on the part of two peoples in harmonizing historic forces with present-day scientific knowledge. The scientific approach, being essentially one of tolerance, sympathy, fairness, and a search for the truth, was the common meeting ground which was primarily responsible for reaching a satisfactory solution.

Solving international problems through the scientific method is something relatively new. The people of the United States, for instance, may well recall episodes of a very different character such as the treatment of the loyalists during the War for Independence; despoliation of Indian tribes; threats of force to determine state boundaries; seizure by force of lands of neighboring peoples; slavery, civil war, and emancipation without representation. This list of illustrative items could be substantially increased. The people of Mexico also can find in their history a corresponding list of incidents indicative of an adolescent democracy finding its place among older nations.

There is no better way in any specific situation involving misunderstanding and irritation among nations than to approach the problem with an understanding of the cultural and other social forces that have contributed to the problem and its technical aspects and with humility and recollection of past delinquencies within one's own nation. This is essentially the scientific approach. The settlement of the oil expropriations by scientific cooperation between Zevada and Cooke within a period of a few months is illustrative of its value.

HERE, too, the Cooperative Program method evolved by The Institute of Inter-American Affairs of our government and the other American republics has proven of value. (The Institute of Inter-American Affairs is a government corporation organized and controlled by the Office of Inter-American Affairs. Cooperative Health and Sanitation and Food Supply Programs are carried out pursuant to agreements between The Institute of Inter-American Affairs and the various Latin-American Republics. A similar government corporation, the Inter-American Educational Foundation, Inc., has entered into similar agreements with the other American republics for the carrying out of Cooperative Educational Programs.) Traditional diplomacy is primarily negotiation between two men; a Cooperative Program is a form of concrete activity between the professional people of two countries, based on science as the common ground, and with the common objective of developing a subject impersonally for the common benefit of the peoples of the two countries.

In the Cooperative Health and Sanitation Programs United States doctors, sanitary engineers, and nurses work directly with the doctors, sanitary engineers, and nurses of other American republics, determining the best methods for the improvement of health and sanitary conditions in the particular circumstances. Doctors, sanitary engineers, and nurses from these countries come to the United States for study and training,

and they necessarily return with a personal, first-hand knowledge and appreciation of conditions and people in the United States. In their own countries the people become generally familiar with our methods and with our medical and engineering equipment. Our textbooks are distributed in Spanish and in English, and the result is the establishment of the technical leadership of the United States in those fields to the extent that it is qualified. Also, the physicians, engineers, nurses, and other experts from the foreign country come to maintain personal and professional relationships with similar professional people in the United States. And, in turn, the members of each Field Party of The Institute of Inter-American Affairs return to the United States with a full, detailed knowledge and appreciation of, and affection for, a foreign country and its people. Here, then, we have genuine collaboration between the professional peoples of two countries, based on a real working together with science as the common ground.

The same is true of the Cooperative Food Supply Programs. Agricultural experts from the United States go to live in a foreign country to work with the Ministry of Agriculture and the farmers. They take with them a first-hand knowledge of modern agricultural techniques and practices, which invariably are well received because they enable the local farmers to produce more and to make more money. Some of these farmers come to the United States for study and training in modern agriculture and farm management. In addition, they become familiar with United States equipment and publications. Hence, in the Cooperative Food Supply Programs the agricultural populations, which constitute the great bulk of the people of most Latin-American countries, actually work with our agricultural technicians, with science or technical skill as the common ground, to accomplish objective results of benefit to both countries.

In the Cooperative Educational Programs distinguished educators from the United States go to the Latin-American countries and work with the Ministry of Education and directly with the teachers in the schools. Latin-American educators come to the United States to study and exchange ideas, methods, and experience. Textbooks and other teaching aids and materials are jointly prepared for use in their countries, embodying advanced ideas and pedagogical methods adapted to the foreign conditions. Here, too, is working collaboration between the professional people of two countries, with science or technical knowledge and skill as the common ground.

The professional people are as a rule the leaders of public opinion in every country. When there is a genuine and substantial close working relationship between them, they are bound to understand and respect each other and the conditions in the other country. Their ideas naturally gravitate toward common denominators and a common point of view on the fundamental factors of society. Such collaboration between peoples entirely transcends the traditional concept of diplomacy, of formal relations between two men or a small group only. It is this sort of active, working collaboration between professional people of two countries, with science as the common ground, which can provide a solid foundation for mutual understanding and respect on a continual day-to-day basis.

With the establishment of such a foundation of mutual understanding and respect between the peoples of the world, international relations must necessarily take on a new aspect and thus provide a new harmony and security for the peoples of the world.

BOOK REVIEWS

THE TASK OF EDUCATION

Problems of Men. John Dewey. 424 pp. $5.00. Philosophical Library. New York. 1946.

THOSE who have read John Dewey's other books on philosophy and education will not find much that is distinctively new in this volume, but they would be ill advised if they failed to enjoy at least some of the timely and stimulating essays it contains. A collection of articles and reviews which originally appeared in various educational and philosophical journals, it is divided into four sections: Part I is concerned with the general problem of "Democracy and Education"; Part II contains essays centering around the subject of "Human Nature and Scholarship"; Part III, the most technical and difficult pages to follow, tackles the complex problem of "Value and Thought"; Part IV gives a brief but rewarding discussion of three philosophers: James Marsh, William James, and Whitehead. The variety of subjects treated in these articles, written at different times and for different occasions, is welded into thematic unity by the author's consistent philosophy of instrumentalism, which he applies boldly to almost every aspect of life and thought: education, ethics, psychology, epistemology, politics, and so on.

John Dewey is a courageous as well as clear-minded spokesman on current educational issues. He believes that teachers cannot—and should not—shuffle off their responsibility for dealing intelligently with the difficult social problems of their time. It is their duty, he maintains, to join professional organizations, to cooperate with labor. This, he feels, would greatly increase their economic literacy and at the same time strengthen their economic position. He protests strongly against the dichotomy established by the proponents of "liberal" education between liberal education and vocational education—a thesis which is also developed in part by another recent book *Education for Modern Man* by Sidney Hook. It is the technical subjects, now so urgently in demand, which must be given a human cast and perspective.

In analyzing the relation between authority and freedom, stability and change, Dewey stresses the need for the application of organized collective intelligence as illustrated by the scientific method. The philosophy of liberalism, too, must be revised, disentangled of its misleading and false elements. Liberalism, as Dewey would like to reconstruct it, would reassume its historic and creative role by recognizing that the individual is not a fixed datum but something achieved in a cultural environment. Liberalism of this type is important because it emphasizes the fact of historical relativity, the factor of change, the idea that the character of the individual and the concept of freedom take on different values in the course of time. It is opposed to absolutism and authoritarianism in any form. Belief in historical relativity validates the experimental method and makes the connection between the two functionally explicit. There is nothing mysterious or forbiddingly technical about the experimental method; it is predicated on the maximum use of pooled social intelligence in the inception and consummation of change and thus stands at the opposite pole of both entrenched conservatism and reckless radicalism.

In replying to the attacks that have recently been leveled against the scientific method and the philosophy of science, John Dewey hoists the Neo-Humanists, the prophets of tradition-

alism, and the metaphysicians of the supernatural with their own petard. He takes up the various charges that have been hurled against science in education. The teaching of scientific subjects is condemned as being too narrow in scope, whereas literary subjects are awarded the palm as being truly humanistic. Science, it appears, concentrates on the utilitarian, the practical, the vocational, thus marking a dangerous trend away from the human and the rational to the materialistic and the expedient. Though Dewey concedes that education today lacks unity of aim, he refuses to acknowledge that this is due to the impact of science and technology. Return to the classical models of the past, the revival of the medieval curriculum, would not be of any help. On the contrary, it would aggravate our hopelessly confused dualistic condition. The task of education is to march ahead, not to retreat to the past. The goal is not to reinstate "liberal" education as proposed by men like Hutchins and Adler but to humanize the content of vocational education, infusing it with meaning and purpose in the light of contemporary needs. To effect a release of human powers, to make for maximal human growth—that is the true meaning of being liberal. The attempt to re-establish educational materials and methods that were adapted to relatively simple conditions in the past is absurd and harmful in practice. It is opposed to all that we understand by freedom in a democratic country like America. The label "freedom" that these "liberal" educators use is but a euphemism. The faith that a miscellaneous collection of the hundred "best" ("best" for whom and under what circumstances?) can furnish an adequate educational diet is nothing short of laughable, Dewey declares. Such "reactionary" movements in education are to be combatted at all costs because they represent a frontal attack on the principle and method of experimental inquiry, the use of first-hand observation, the reliance on scientific method.

The same strictures apply, Dewey argues, to the disputed field of morals, which he also subjects to scientific analysis and evaluation. The notion that the One and the Changeless is somehow superior to the phenomenal world of change must be hooted and booted out of court. Improved instruments of observation and experimental techniques reveal change and continuity everywhere in life. Equally pernicious is the belief that the subject matter of natural science is restricted in scope and of subordinate importance, confined to technical or practical matters. A dichotomy is thus introduced between naturalistic means of knowing and realms of spiritual or moral values where science must not intrude. But the factors of supreme importance actively at work in contemporary life are experimental science and experimental method in *all* fields of knowledge. The breach between "higher" and "lower," the supernatural and the natural, the practical and the ideal, has worked enough mischief; it must now be bridged once and for all.

Science is making steady advances in practically all departments of life. Hence it follows that science must be applied to the domain of social and moral knowledge as well as to purely "material" concerns. Why postulate an irreconcilable antinomy between science and morals as if the truths of morals are different in kind from those to be found in physics and biology? Fundamentally, the issue is one between consolidated dogma and experimental insight, authoritarian conclusions and intelligent observation controlled by the wisdom of experience. All this is in line with political democracy, which endeavors to settle differences by the open discussion and exchange of ideas, an ap-

proach which approximates to the scientific method. It is the opportunity as well as responsibility of philosophers to make clear this deep connection between democratic processes and the scientific method.

The defense of science and the scientific method constitutes the spinal thread of the book. Science is being assailed on the ground that it has no relevance to essentially human, moral, and social problems. The quarrel boils down to this: Who shall be given the authority to direct life? Dewey contends that there can be no divorce between pure and applied science. Empirical philosophy looks upon science as being the only discipline that provides valid means for learning the truth about man and the world in which he has his being. Such acknowledgment of the value of science does not destroy the need for philosophy, which still has a vital function to fulfill. Philosophy makes it possible for man, once he has obtained the fullest possible knowledge about himself and his environment, to decide what ends he should pursue and what means can best realize them. There is urgent need for applying the scientific point of view in the schools. The established scientific curriculum is inadequate because the subject matter of science is still treated as a special and separate body of facts.

If the authority of science has tended to decline in our day there must be "good" reasons for the decline. Science first won its signal victories in transforming beliefs relating to "practical" matters. It ousted superstition and wishful thinking, it revolutionized commerce and industry, and so it seemed as if science were a highly specialized activity reserved for scientists in the laboratory, not a frame of mind with which human beings confront the challenging problems of life. Yet that is the goal which ultimately has to be reached. The material applications and technological triumphs of science are but the negative side of the picture. The experimental method of intelligence has never yet been used and applied to social problems. The vast knowledge we have gained in the physical sciences must be paralleled by an equally fruitful degree of progress in knowledge that can be applied to human desires and purposes. For human nature is not unchangeable; it is indefinitely plastic and malleable. Education can be put to use to create new ways of thinking, feeling, and believing. Dewey is convinced that when the science of man is developed to as high a pitch as physics or chemistry, it will concern itself with the fundamental problem of how most effectively to modify human nature.

That, substantially, is the message Dewey articulates in *Problems of Men,* a book which carries on the ideas and the faith to which he has devoted himself over a long and remarkably productive career.

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THE STORY OF AVIATION MEDICINE

Through the Stratosphere: The Human Factor in Aviation. Maxine Davis. 253 + viii pp. $2.75. The Macmillan Company. New York. 1946.

THIS is an incredible book. It is unbelievably comprehensive, and one which truly accomplishes what it sets out to do. It does this, moreover, in an effective, easy, reportorial style. This is accomplished in spite of the necessity for telling many complicated details: the necessity of narrating technical explanations which are essential to the story. What is this story?

The opening sentence of the book states: "This book is the story of aviation medicine." This is true. One must recognize, however, the basic fact that "aviation medicine" embraces all that

body of knowledge, practices, and beliefs which pertain to the *welfare* of the flyer —in this case of the Army Air Forces. Aviation medicine begins, for the flyer in the AAF, with selection, both on psychological and medical grounds; it continues in the field of preventive medicine and physiological hygiene where training the flyer is concerned with the care and use of all the equipment which is necessary to enable the flyer to cope with altitude, pressure, accelerations, impacts, and other aspects of flying in an environment which is strange to earth-bound man, and in situations too hazardous to be sought after by men accustomed to comfortable and routine domestic lives. Aviation medicine strives to judge the fitness—both physical and psychological—of the flyer and to admit to flying status only those whose performance of their duty is not a liability to themselves and to their companions. It initiates, advises, and supervises the design and development of special equipment. All of this is set forth—interestingly, compellingly—in this book.

The method of telling the story is simple. There are six sections in the book, with one to nine chapters each. The first is orientation—or setting the backdrops of an all-inclusive cyclorama. Miss Davis tells us that she spent a total of three months in virtually every active, combat U. S. air force around the world. She traveled over 35,000 miles by air. She saw, apparently, whatever she needed to see or desired to see. Most important, she had expert guidance both in the field and at home. The second section is the story of assembly-line applied psychology—that of cadet selection. This is *the* story in words that the high school student can understand. Next is a section on the special environment of the flyer, off the ground. This sets the stage of the story and prepares the way for the fourth section. The fourth deals, one by one, with specific problems of combat flying and the means by which they were solved. A fifth section is concerned with survival and rescue in the jungle—and the "rescue" of men whose minds have broken, for a time, under the stress of living on the false ground swell of combat. The final section does honor to the flight nurses, to the system of air evacuation, and hospitalization. In each chapter, the technique of telling the story is similar: state the problem, give examples for illustration, then tell the solution which the air forces through the air forces medical services adopted.

Miss Davis has obviously had available to her many official documents and very expert guidance through headquarters, AAF, and in the combat air forces from top to bottom. To anyone who knows the emphasis on certain topics and the history of certain developments as situations arose during the war, it is clear that Miss Davis had the "official line." It is correctly set forth, no doubt about it. To those who shared in these situations when what is now history was then the present—or worse, unknown—the development of this story was at times more hectic and less planned than it is made to seem in this book. For example, in the story of the "Air Force's Handy Man," the Personal Equipment Officer is made to sound as if, when the need was obvious, he of course had the solution—before too long. Would that this had been so! It is a fact that when nearly a hundred officers had been brought from every part of the country to Florida for three-week periods over a period of five months—at considerable cost in E bonds—there was no recognition on the part of top sides—from Headquarters AAF to headquarters of many of the Air Forces—sufficient to provide more than "paper" backing to the original directive of General Arnold that the duties of this officer would be fulfilled in every flying unit in the army air forces. This

was true to a lesser extent of other developments in which many high-ranking officers take pride today. Except for the force and foresight of a handful of men strategically placed in the air forces and in headquarters, the over-all program would have been far less successful than it was. Miss Davis rightly stresses General Grant's role as Air Surgeon. It is a fact, moreover, that certain officers from the Office of the Air Surgeon were insistently forceful, so that it is now possible to tell this story well, as has been done in this book. Many statements are exaggerated, but justifiably so, for their storytelling effect. The name of this book—*Through the Stratosphere*—has little bearing on its content. On the other hand, the subtitle—*The Human Factor in Aviation—is* the story! Part of the same reportorial exaggeration appears effectively in telling how meals were available on long hops with the ATC. This does not fit the case in some instances. After conditions became stabilized the situation did improve. But the description of delicious meals served in the sky is a taunt to the memory of this reviewer who, on an eleven-hour jump over the Sahara from Marrakech to Dakar, was required to pay one American dollar for a single chicken sandwich delivered mysteriously to the airport from the *boulangerie et patisserie de M. Marmouk,* or some such name. Some five hours later, it was less than reassuring, with this as the only food around, to see across the aisle a flight-companion struggling with his half-eaten sandwich from which protruded amidst the lettuce a fat, squirming worm of doubtful antecedents and associates. There are a few gaps in this book, but it would be as unwise as it would be impossible to tell the entire story. One wonders, for example, how there is only passing allusion to the notable work of a group of aviation physiologists whose effective work in altitude indoctrination brought results, if not recognition. It is a wonder to the reviewer how Miss Davis ever flew around the world and over the Hump without passing through even a single indoctrination "flight" in an altitude (low-pressure) chamber. Even "chairborne pilots" were indoctrinated—by the hundreds, if not thousands. One suspects that Miss Davis did not see at first hand the work of the training forces in the United States.

Still another omission or oversight is the flak suit—a most notable contribution to the success of our combat flyers, which originated in the aviation medical services. It receives but scant treatment in proportion to its value and that of some other topics included in the book. Similarly, while there is some reference to the role of dinghy drill and air-sea rescue in general, it is a fact that the agency in the air forces which made the operational training units accept the necessity for adequate training and preparation of the air crew in air-sea rescue training was the medical department. To one who has sat alone in a dinghy in the Irish Sea, off the Delta of the Wyr in mid-December, and then seen forty, fifty, and even sixty American men go down in the North Sea (noted on a large map in the Control Center at Chatham in the Thames Estuary but unsaved), the success attending American efforts to prepare the flyer to save himself takes on real meaning. The Office of the Air Surgeon was probably as responsible as any other single agency for the record of success that attended Air Forces' efforts in this direction, through initiating training and through persistence.

These are small points beside the success which Miss Davis has achieved. Her book should appeal to families and friends of men who fly; to the thousands of unsung ground-echelon men who lost, or never had, a perspective of the whole stage on which their little act was played, monotonously perhaps, but

where it was nevertheless a vital role. There is a breezy femininity about this book that makes it a distinct pleasure to recall regulations, circulars, letters, and orders. If the layman is momentarily fazed by reference to a "full-blown vicious circle of peripheral circulatory insufficiency, tissue anoxia, and marked hemo concentrations," he may find a moment of pleasure in associating this *hemo* with a brand of chocolate milk enricher available on the shelves at the local supermarket. He will not have lost much in not knowing the nickname of hemoglobin. For this reviewer, it brought back a fading memory of the time when *hemo* had no other meaning than that of a quick, one-glass lunch, to be eaten in three minutes while standing at a Snack Bar in the Pentagon. "Ulcer Clinics," we called 'em.

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PROLEGOMENA TO AN INQUIRY IN THE PROBLEMS OF MEDICAL CARE, III*

A Future for Preventive Medicine. Edward J. Stieglitz. xiv + 77 pp. $1.00. The Commonwealth Fund. New York. 1945.

This monograph is the third of the now well-known series initiated by the New York Academy of Medicine Committee on Medicine and the Changing Order in its effort to secure objective data on the reciprocal effects of medicine and the technological, social, economic, and political changes that have taken place in American life. The Committee believed that such monographs will offer not only a survey of the present situation but will also indicate its evolution and possible future trends.

Dr. Stieglitz presents his discussion of a future for preventive medicine under four headings, as follows: I, Definitions; II, Health Over the Last Forty Years; III, A Program for Preventive Medicine; and IV, Summary. His discussion is based upon a definition of preventive medicine which includes two broad areas of operation characterized by the mass and individual approach, respectively. The mass approach attempts to control the environment, making it innocuous, such control being the responsibility of the public health and sanitary services. The individual approach, on the other hand, has for its objective the prevention of undue health depreciation by attempting *construction* of greater individual health.

The author points out that present-day medical practices place relatively little emphasis on the individual approach. Interest continues to be centered on disease rather than on health, which should be a major concern of preventive medicine. Three factors appear to be responsible for this situation: Unwillingness of the individual to assume responsibility for his own misfortunes; inadequacy of present knowledge of causation of disease, particularly the failure to recognize that causation is always a combination of many factors; and the precept of medical ethics forbidding the practitioner to give guidance unless his aid is voluntarily sought. The last factor is qualified with the thought that "until people as a whole are educated to the point where they will cease to wait for pain, weakness, or fear to drive them to their physicians, preventive medicine will continue to be the backward child of medical practice."

The second section of the monograph presents a thoughtful statistical appraisal of health in the United States over the past forty years with appropriate emphasis on the changes in age structure of the population. The author proceeds to discuss the age factor in its relation to the two major areas of preventive medicine, the environmental con-

* Monograph I was reviewed in The Scientific Monthly, 60: 319–320 (April 1945); Monograph II in the same journal, 60: 471–473 (May 1946).

trol and the health practices associated with the individual. In the first instance the etiology is exogenous and obvious; in the second it is endogenous, occult, cumulative, multiple, and distant in time. The onset, on the one hand, is florid; on the other, insidious and asymptomatic. In the infective disorders typical of youth the course is acute and self-limited, with immunization and little individual variation; the degenerative disorders common in senescence are chronic, progressive, nonprotective, and present great individual variation. The author concludes from these observations that a preventive program, if it is to go beyond environmental control, "must remain a hope until such time as the complex etiological patterns of these [degenerative] diseases are thoroughly understood."

The second section also presents an opportunity to the author to record briefly some thoughts on the profound effect of progressive disability on the family, on the community, and on society in general. The author questions the soundness of the doctrine that the strong shall help the weak and so introduces a number of corollaries which will not be found particularly acceptable to some of his readers. The whole subject with its many ramifications is broader than the discipline of preventive medicine itself, and perhaps Dr. Stieglitz will devote a volume to it at some later date.

The third section is devoted to a program for preventive medicine, all recommendations being considered by the author as tentative suggestions. Development must be along both mass and individual lines. As has already been indicated, the first has to do with measures minimizing health hazards in the environment, whereas the second deals with private health efforts concerned directly with the individual, hoping to increase his ability to cope with unavoidable, undesirable environments.

For the advancement of preventive medicine the following activities are suggested:

(1) Continuation and expansion of the present public health approach; (2) further research into the epidemiology of diseases guided by current data on morbidity and mortality; (3) coordination of preventive and health activities; (4) health education under the direction of physicians; and (5) introduction of individualized constructive medicine for adults.

Dr. Stieglitz has performed his assignment well. I would direct attention particularly to the author's emphasis on the necessity for shifting the focus of medical practice from the disease to the patient; his reminder that the causation of disease is always a combination of many factors; his recognition that the pictures displayed by the morbidity and mortality data of a given population are by no means identical; his insistence on the availability of morbidity and mortality data for the purpose of determining where, when, and under what conditions ill-health is occurring; his definition of preventive medicine which he has expanded to include health construction; his expansion of the conventional objectives of therapy to include that of control; his presentation of the elements differentiating the mass approach from the individual approach, particularly the role played by the patient: in the individual approach the role is an active one, whereas in the mass approach the role is largely passive, requiring little effort and interest; and finally his firm belief that health is a privilege, and hence there exists a personal responsibility for health maintenance which is an obligation to family and society as well as to self.

The book has a good bibliography and index. The typography and binding are uniform with the two earlier volumes of the series.

I feel that some reference might have been made in the monograph to the "Peckham [England] Experiment," be-

gun in 1926, which makes use of the family as the unit for individual health maintenance and health building. A cursory examination of the well-chosen bibliography revealed two minor errors.

This interesting, well-written, and thought-provoking book is unhesitatingly recommended to all health workers and others interested in making possible optimum health for the citizenry of this country.

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HAUSMAN'S FIELD BOOK

Field Book of Eastern Birds. Leon Augustus Hausman. xvi + 659 pp. Illus. $3.75. G. P. Putnam's Sons, N. Y. 1946.

This volume is an addition to the well-known series of "nature field books" published by Putnam's. However, unlike most of the other volumes in the series, it is not a manual for a group hitherto not so treated and consequently it will have to compete with established favorites, such as Peterson's *Field Guide to the Birds . . . Found in Eastern North America* and Chapman's *Handbook.* More abundantly illustrated than Chapman's volume, the present book is less adequate in this regard than Peterson's, although nearly every bird is figured, mostly in little black-and-white cuts which do not lend themselves too readily to comparison. The six colored plates containing 94 birds are not too well printed, the colors being too bright and losing the subtle modulations of tone that the originals probably had. The birds are very well drawn; their poses and action are good. All the illustrations are the work of a newcomer to the ranks of bird artists, Jacob Bates Abbott. Unfortunately, a few of the black-and-white sketches, such as those of the purple finch and the summer tanager, are in themselves not particularly identifiable.

Each bird has a separate page devoted to it, headed by the common name, the scientific name, the size, and a black-and-white drawing of the bird. Immediately below this figure each page has the pertinent text divided into conveniently marked paragraphs: Other Names, Field Marks, Field Description, Characteristic Habits, Notes, Habitat, and Range. Besides this, each family is prefaced by a Field Key, while the main body of the book is started off with a Field Key to Bird Families. A bibliography and an index complete the volume.

As a field book the present work suffers by being heavier and thicker, less adapted to a pocket, than Peterson's slender volume and seems to the reviewer less readily usable for quick identification in the field. On the other hand, Hausman gives the reader more information about each bird than does Peterson. The number of bird students is so large, however, that some will no doubt prefer Peterson's type of book and some Hausman's.

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SCIENCE ON THE MARCH

BAFFLING FOSSILS

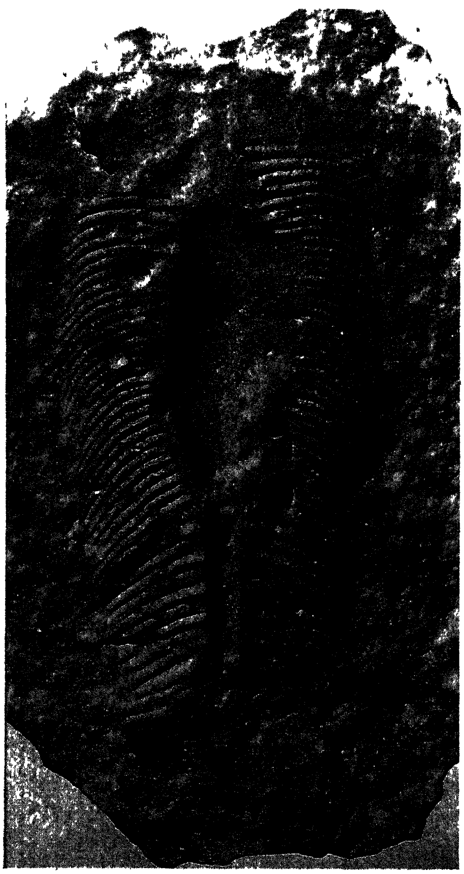
Of all the extinct multitude of plants and animals that once inhabited the land and waters of the earth only a relatively small number left identifiable remains or traces as fossils. This incomplete fossil record, although a challenge to the reconstructive talents of the paleontologist, is, nevertheless, often dismaying, particularly when the dating of strata is urgently desired. Many fossils, obviously, have no living counterparts, and the paleontologist accordingly must erect categories of classification based on such analogies as he can find. Other fossils, although their relationships may be transparently clear once the correct clue to their identity has been found, may remain unidentified for years as tantalizing, baffling objects. In my office at the United States National Museum I have a drawer marked "Unsolved Mysteries" for the reception of such unknowns until time, patience, and further information bring enlightenment. Recently I had the satisfaction of solving one of these mysteries. The story, in detective style, might be called "The Case of the Fossil Fish Eggs."[1]

In the 1870's, Orestes St. John, a geologist studying the coal-bearing strata near Raton, N. M., found many specimens of fossil plants, including large fan-shaped impressions of palm leaves. These eventually reached the National Museum where they were studied and stored. About ten years ago, when curating this collection, I discovered among the palms several curious impressions that, presumably because of their markings, had also been considered palms. Some features of these impressions, however, seemed to me not characteristic of palms nor, for that matter, of any other organisms with which I was familiar, and I therefore removed the specimens to the drawer of problematica. Nothing further developed in this connection until late in 1944. Returning from field work in Alaska, my colleague Don J. Miller, of the U. S. Geological Survey, brought in a collection of fossil plants among which was a well-preserved impression that immediately reminded me of the puzzles from New Mexico. With this spur and the recognition that all these fossils were collected from brackish water or marine strata, I redoubled my efforts at identification by turning from the consideration of fossil plants to possibilities among marine animals. Thus I was presently led to the reading of a paper by Theodore Gill in 1905 reporting an egg capsule of a chimaeroid fish collected by N. H. Darton from Cretaceous strata near Laramie, Wyo. When I brought my specimens and conjectures to C. W. Gilmore, late curator of fossil vertebrates at the National Museum, he astonished me by producing Gill's specimen, of the location of which I had been unaware. It clearly confirmed the identification of the New Mexican and Alaskan fossils as similar egg capsules. Delving further into the literature I then found that Gill had been preceded by Emil Bessels, who in 1869 identified chimaeroid capsules taken from Jurassic strata in Germany. These had puzzled a scientific society at Württemberg for forty years, some members thinking the specimens represented crustaceans.

The chimaeroid fishes, named from the genus *Chimaera,* are sharklike in appear-

[1] Brown, Roland W. Fossil egg capsules of chimaeroid fishes. *J. Paleontology,* 20: 261–266. 1946.

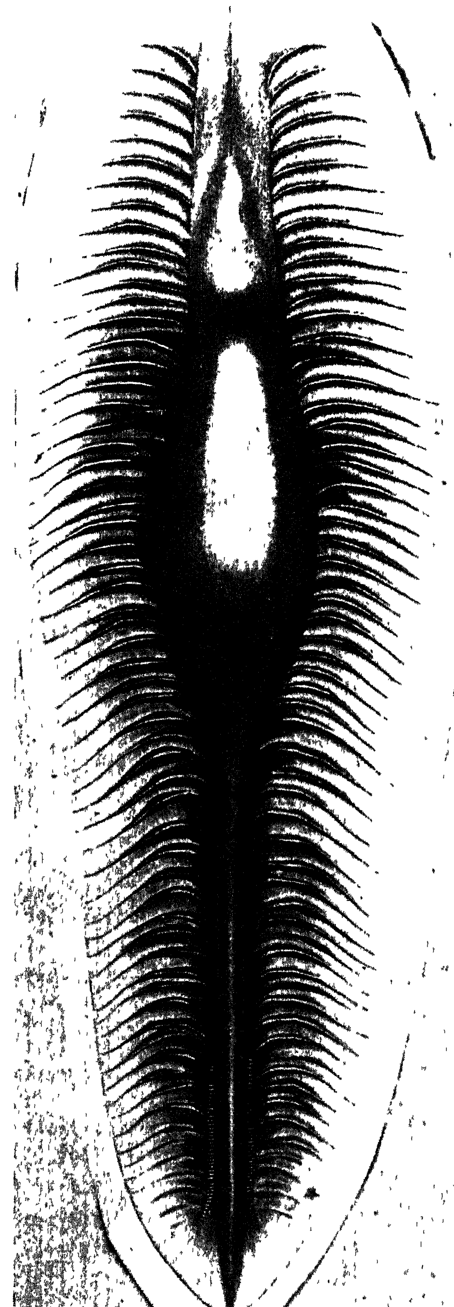
ance but are neither sharks nor ancestral sharks. Today they comprise about twenty-five species. They occur in all parts of the world, some in shallow, coastal waters, and others at abyssal depths. They display varied coloration, have powerful dental plates, and reproduce by laying dartlike or elliptic, tough, leathery egg capsules, somewhat after the manner of modern skates. These capsules consist of a central embryo case that is surrounded by a thin membrane of variable width with riblike thickenings, simple or branched. At the proper



.52 natural size

FIG. 1. FOSSIL EGG CAPSULE

SPECIMEN SHOWING THE CENTRAL EMBRYO CASE SURROUNDED BY A THIN RIBBED MEMBRANE. FROM THE CRETACEOUS NEAR LARAMIE, WYOMING.



.78 natural size

FIG. 2. LIVING EGG CAPSULE

THIS CAPSULE, DEPOSITED BY A CHIMAEROID FISH, WAS COLLECTED NEAR MISAKI, JAPAN.

moment a valve on the lower side at the fore end opens and permits the young fish to escape. The adult fish is approximately four times the length of the egg.

The fossils compare well with the egg capsules of a number of different genera of chimaeroids. Gill's specimen (Fig. 1), for example, is very similar to the capsule of the living *Rhinochimaera pacifica* from Misaki, Japan (Fig. 2). Eight fossil specimens are now known, and these I have divided among six species—two from the Jurassic; three from the Cretaceous, and one from the Oligocene. Judging from the large number of species assigned to the chimaeroids on the basis of fossil teeth, one must suppose that the Cretaceous was the heyday of these fishes. As the fossil egg capsules occur in strata that represent deposition in relatively shallow brackish or marine water, they may be valuable for stratigraphic purposes when they become better known.

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RIBOFLAVIN AS A FACTOR IN THE ADEQUACY OF THE AMERICAN FOOD SUPPLY

IN 1941 the Williams-Waterman Fund of the Research Corporation made a grant to Columbia University in aid of a survey study of riboflavin as a factor in the problem of the nutritional adequacy of the American food supply.

The plan was to ascertain from critical compilation of previously published evidence, supplemented by additional determinations where needed, the riboflavin content of the average American food supply and to compare this with the nutritive requirement as found by other investigators.

Our starting point was the annual per capita consumption in the United States of each article of food which plays a significant part in our nutrition. The quantities of food commodities thus used were those derived by Lane, Johnson, and Williams[1] from official sources; these were also used by Cheldelin and Williams[2] for similar estimates of other vitamins of the B group.

Cheldelin and Williams'[2] estimate of riboflavin consumption in the United States was 1 4 mg. per capita per day before, and 1.6 mg. after, the introduction of flour and bread enrichment.

Applying to the same data of commodity food consumption new averages for riboflavin contents of foods, we estimated the (U.S.A.) per capita consumption at 1.8 mg. of riboflavin per day. That our estimate was higher than that of Cheldelin and Williams is owing to the fact that our average findings for riboflavin in individual foods, obtained by collating all available evidences from previous work as well as that of our own laboratory, tended to run somewhat higher than the averages of the determinations made by Cheldelin and Williams and used in their estimates.

Our experience indicates that with many foods more precautions are needed if the assay methods now commonly used are to reveal the full riboflavin content. We have not, however, been able to investigate this point as fully as seems desirable. Of late there has been a natural inclination to adopt as conclusive any findings in which *in vitro* determinations and micro-bioassays agree. There is, however, still the possibility—not only theoretical but concretely suggested by some very careful animal-feeding assays —that both the *in vitro* method and the micro-bioassay may yield low results with some foods. An unprecedentedly comprehensive research upon the quantitative determination of riboflavin in foods of all types and using all three types of assay (*in vitro*, microbiological, and animal feeding) might be well justified.

Meanwhile the United States Department of Agriculture has made new offi-

cial estimates of annual per capita consumption of foods by our civilian population. Also, newer figures for average riboflavin contents of foods have come into use. The data determined in the Columbia University laboratories have been merged with other data by the U. S. Department of Agriculture and the whole combined with data gathered by the National Research Council in making the table of nutritive values of foods now published through the Government Printing Office as *Misc. Publ. 572* of the U. S. Department of Agriculture.

These data lead to estimates[3] that our average riboflavin intake in the United States was in 1935–39, 2.0 mg., and in 1943, 2.3 mg., per capita per day. This gain of 15 percent is attributable in part to the enrichment program and in part to the gradually growing use of milk in our national dietary.

In 1941 the National Research Council published the now familiar Recommended Dietary Allowances for people classified according to age, sex, and activity. Those for riboflavin corresponded to a recommendation of 2.2 mg. per capita; but in the revision of 1945 the figures for riboflavin corresponded to 1.8 mg. per capita per day.[4] This change is because of downward revision of the allowances for adults (other than women in pregnancy and lactation), based chiefly on the findings of experiments such as those of Keys and coworkers[5] with young men. These experiments as reported by their authors "indicate that normal young men suffer no physiological or clinical handicap by restriction to an intake of riboflavin of 0.31 mg. per 1,000 calories for a period of five months. . . . Undoubtedly such a restricted diet does not provide a body reserve as large as would result from a greater intake.". By comparison with such experimental evidence as this alone, it would appear that even the 1945 recommendations of the National Research Council carry a comfortable margin of safety; but there are other facts that should be considered lest we indulge a mistaken sense of security.

The five months' period of riboflavin restriction in the above experiments is only a fraction of one percent of a normal human lifetime. From animal experimentation we know that similar riboflavin restriction, extended over much longer segments of the life cycle without evidence of handicap, may yet result in premature aging and must be expected to shorten life. Hence a "code" of recommended allowances set up to cover all ages—and so, by implication, entire lifetimes—should in our opinion not be so much influenced by experiments covering only a very small fraction of (presumably) the most resistant part of the life cycle. For, the more comprehensively the evidence is studied, the more clearly it appears that riboflavin allowances should provide liberal margins. Two distinct reasons combine to support this view. First, when we extend our consideration to successive generations, animal experimentation shows that even at levels so liberal that further increase of intake has no further effect detectable in the original subjects, offspring may yet derive additional benefit from higher levels of intake of riboflavin in the family dietary.[6]

A second major reason for seeking liberal levels of riboflavin in our American food supplies is the fact that distribution is very uneven. With an *average* intake only slightly above minimal adequacy, an undue *proportion* of family dietaries are in constant danger of a shortage of riboflavin. There are both geographic and economic areas of undue hazard in this respect. The several governmental studies made by Stiebeling, Phipard, and others, show a high proportion of low-riboflavin dietaries among Southern families. This is clearly attributable in part to the geographic rea-

sons for shortage of milk in much of the South. But it is largely economic because in the North also low-riboflavin dietaries are found rather frequently among low-income families, especially those living in cities.

We must therefore conclude that inadequacy of dietary riboflavin is a more prevalent hazard in the United States than would appear from a merely casual consideration of current estimates of food supplies and nutritional requirements. There is need of more comprehensive and critically precise knowledge both of the riboflavin contents of foods and the riboflavin requirements and interrelations in metabolism, as well as the significance of bodily stores of riboflavin to individuals and their offspring. Meanwhile, in the interest of nutritional well-being and public health we should seek, as matters of public policy, both the fullest possible development of the enrichment program and a larger use of riboflavin-rich foods among low-income people. Fortunately, the food management policy which looks to wiser conservation and use of protein should also result in raising the level of riboflavin contents of low-cost dietaries.

Further research will doubtless make clearer the significance of riboflavin in nutritional well-being, and with increase of clarity should come increase of educational and governmental emphasis upon this important factor in the nutritional improvement of life.

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THE ACTION OF INSECTICIDES

EVERYONE must have marveled at the delicate mechanism of a woman's wrist watch, but it is a gross machine compared with the mechanism of an insect. Even a gnat that is barely visible has within its body nearly all the organ systems of an elephant, though they may be differently arranged. An insect has no bones in its body, but its skin, or integument, is sufficiently tough and rigid to support the muscles that move its wings or legs or mouth parts. It has an elaborate nervous system, sensory and motor, to enable it to find food and mate and avoid enemies. Its alimentary tract may be a tube leading straight from mouth to anus or it may coil and have blind alleys and by-passes along the way. It has no lungs, but, instead, tiny branching tubules, called tracheae, conduct air from openings (spiracles) along the sides of the body to all the tissues of the interior, eliminating the need for blood as an oxygen-transporting medium. The insect has a rather colorless blood, however, which is pumped by a tubular heart along the back from the tail to the head and circulates from head to tail through spaces and channels among the tissues. The excretory system, reproductive system, and perhaps an endocrine system need only be mentioned here.

The most numerous of terrestrial animals, insects have adapted themselves to all habitable environments, except the oceans. There is probably nothing of natural organic origin, living or dead, that does not provide sustenance for some species of insect. Reflecting their diversity, insects differ in structural de-

tails. One of the most important differences, from the point of view of chemical control of insect pests, is in the mechanism of feeding. Insects that consume solid foods, like the leaves of plants, can be killed by poisoning their food with so-called stomach insecticides; insects that consume liquid foods, sucking the sap of plants or the blood of animals, cannot be so killed. However, both kinds of insects may be killed by contact poisons, which, in contact with the surface of the body, enter it by some route other than the mouth. And both kinds may be killed by fumigants, the vapors of which enter through the respiratory system.

It has not been difficult to find chemical compounds that will kill insects; but it has been and remains difficult to find new compounds that give good economical control without injury to the insects' host or enemies or without hazard to the person handling or applying the insecticide. The human hazard is, of course, the most important, and the great differences between human and insect physiology suggest that there may be, awaiting discovery, chemical compounds that are lethal to insects and harmless to man under conditions of use. So greatly do conditions of use vary for different pests that no one insecticide is likely to solve the problem.

In the early days of chemical control entomologists were willing to use any economical poison that did little or no damage to the plant or product to be protected against insect attack. Thus poisons known to be deadly to all forms of animal life were used: arsenical stomach insecticides; nicotine contact insecticides; and hydrocyanic acid gas as a fumigant. It was hoped that accidents would not occur, but they have occurred and will happen again until more specific insecticides completely replace these toxicological blunderbusses.

Pyrethrum, the dried and ground flower heads of a kind of daisy, was the first effective but safe insecticide to come into use. It was not discovered by scientists but somehow emerged in Europe during the past century. As a contact insecticide it has a spectacular paralytic effect on many insects but has no effect on man, except for a few who are allergic to it. For many years entomologists wondered what compound could be responsible for the unique effect of pyrethrum If it could only be isolated and identified, they thought they would hold the key to a storehouse of insecticide treasures. Finally in 1924 the answer came from Switzerland. Staudinger and Ruzicka reported that two complex esters, which they named pyrethrin I and pyrethrin II, were responsible for the insecticidal action of pyrethrum. Their work was confirmed by others, but the long-sought key eluded everyone. Knowledge of the molecular structure of the pyrethrins did not lead to the development of a single related synthetic insecticide. The slightest change in the pyrethrin molecule destroyed its toxicity.

Insecticide chemists and entomologists did not give up, however. They studied the tropical fish-poisoning plants called derris and cubé, isolated the active ingredients, determined the structural formulae of rotenone and related compounds, which were entirely different from the pyrethrins, and developed products of rotenone-bearing plants into widely used stomach and contact insecticides, second only to pyrethrum in safety to man. But again the knowledge of the complicated formula of rotenone did not lead to its commercial synthesis or to the synthesis of effective insecticides related to it. Like the pyrethrins, rotenone and its close relatives were unique. Nor has any other plant yielded the key to synthetic insecticides.

While the key was being sought by a study of natural insecticides, entomologists were trying all kinds of synthetic

organic compounds, hoping by hunch or by dumb luck to stumble upon an effective compound having desirable properties. Thus phenothiazine was turned up by a group interested in sulfur compounds. Its promise as an insecticide was not fulfilled, but it did prove to be a valuable anthelmintic.

Then in the nick of time (1942) came DDT [1-trichloro-2,2-bis (*p*-chlorophenyl) ethane] from Switzerland and a little later 666 (hexachlorocyclohexane) from England, both chlorinated compounds so simple in structure it was hard to believe that they had been previously overlooked.

The long, random, and often futile search for synthetic organic insecticides indicates that not enough effort was made to understand the toxicology of known organic insecticides or the biochemistry and physiology of insects. In the equation, insecticide + insect = death, the term "insect" was practically unknown as a physicochemical factor in the reaction. Efforts are now being made by a young and enthusiastic group of insect physiologists to develop intelligent hypotheses that can be tested and used to replace hunches in the search for still better insecticides. They want to know how insecticides kill insects. The "how" of lethal action involves at least two questions: how does the insecticide get into the body of an insect and what happens to it and to the insect after it gets there.

A stomach insecticide does not enter the body of an insect until it, or some reaction product, passes through the walls of the alimentary tract; a contact insecticide must enter through the outer integument of the body. It would not be hard to understand how a water-soluble insecticide might enter, but most good insecticides are highly insoluble in water, since their residues on treated surfaces are expected to resist weathering and retain their effectiveness for some time. DDT, for example, is so insoluble in water that only about one part per billion dissolves. How then can it pass through the chitinous cuticle of insects? To answer this question much needs to be learned about the microscopic and submicroscopic structure of the insect cuticle and its chemical and physical characteristics. It is known that the cuticle consists of at least two distinct layers: a very thin waxy outer layer and a much thicker inner layer, which always contains protein and usually a carbohydrate called chitin. The inner layer may be subdivided into a hard outer part and a soft inner part, the latter containing more chitin than the former. These layers may be laminated and penetrated by pore canals and sensory and gland cells. But much remains to be discovered by the use of biochemical methods, X-ray analysis, and the electron microscope.

The modern approach to the question of how insecticides kill may be illustrated by summarizing two papers that appeared in the April 1946 issue of the *Biological Bulletin*. The first by A. Glenn Richards and Laurence K. Cutkomp turned up a surprising affinity between DDT and chitinous cuticle. Their purpose was to study the relative susceptibility of aquatic invertebrates to DDT. Working at Woods Hole where they could get representatives of the various phyla from protozoa to arthropods, including insects, they prepared very dilute suspensions of DDT in fresh water or sea water in which to immerse the various organisms. Samples of each species of animal were placed in a series of suspensions of known concentrations, and the effects of DDT on them were observed. Only the chitinous arthropods and certain coelenterates were highly sensitive to DDT. The susceptible coelenterates had a chitinous perisarc; the resistant coelenterates did not, nor did other resistant animals have a chitinous cuticle. So it appeared that insects were

sensitive to DDT *because* of their chitinous cuticle and not in spite of it. Going further, they found that adsorption of DDT from the dilute suspensions by chitinous cuticle and consequent concentration of the insecticide on the surface of insects was the first step leading to their great susceptibility. They demonstrated the actuality of selective adsorption in various ways: They found that charcoal, isolated insect cuticle, and pure chitin would remove DDT from dilute suspensions, making the filtrate harmless to their biological indicator, mosquito larvae. And then they could recover the DDT from the cuticle and kill the larvae. Furthermore, they found that in the most dilute suspensions the effect on the larvae decreased with increasing temperature. As the quantity of a material adsorbed also decreases with increasing temperature, the unusual negative temperature coefficient was a strong indication of the predominant role of adsorption of DDT in the effects observed. But various other observations showed that adsorption, though important, was not the whole story. Here, however, is a new hypothesis bearing on contact action of insecticides. In searching for new contact insecticides a test for adsorption by insect cuticle might very well be used.

Reporting his work in the other paper, Dietrich Bodenstein explored the internal phenomena. He injected DDT into the body cavity of larvae and adults of Drosophila to determine its locus of action. It was already well known that DDT poisoning in insects is characterized by symptoms of hyperactivity and discoordination of the neuromuscular system followed by convulsions and terminating in death. These effects suggest action on the nervous system but more conclusive evidence was needed. Bodenstein found that a certain paralytic drug, phenobarbital, would prevent convulsions in Drosophila if injected prior to DDT or would stop convulsions if injected after DDT. Because a drug acting on the nervous system stopped the symptoms normally produced by DDT, it was reasonable to conclude that DDT acts upon the nervous system also.

Everyone who has seen tiny Drosophila, sometimes called pomace flies, must realize the delicacy of technique required for these injection experiments. But still more amazing were the subsequent experiments of Bodenstein in which he transplanted from larvae nearly dead from DDT to normal larvae or adult flies the tiny groups of cells called imaginal discs, which upon metamorphosis from larva through pupa to adult develop into the wings, legs, etc. These transplanted imaginal discs developed normally in their new hosts, indicating that DDT affected nerve cells only.

It might be added that the war is responsible for the present increase in knowledge of the action of DDT and other insecticides. Supported by the Chemical Warfare Service and the OSRD, many fundamental investigations have been made, and the resulting stimulation to research in insect physiology and toxicology should be evident in the future.

F. L. CAMPBELL

COMMENTS AND CRITICISMS

Our Everyday Reckonings

Professor Oystein Ore evidently needs someone to tell him that an article on the metric system, either pro or con, is by this time something worse than "old stuff"—thrice threshed straw that Americans—those who have any claim to speak on the subject—ceased picking over thirty-five years ago. The fact that an occasional bill is introduced into Congress, at the instance of some uninformed individual to make it compulsory surely does not warrant renewing the agitation on the old lines with which all of us—*engineers* at least—are so wearily familiar. There is not one single argument rehearsed by Professor Ore that was not thoroughly "winnowed out twixt world and world," like Tomlinson's soul, in my paper "The Metric vs. the Duodecimal System" given before the Am. Soc. Mechl. Engrs. at their fall meeting of 1896 and the appended discussions; plus the numerous writings on the subject by *engineers*—I will not say scientists—in the years that followed. If the metric controversy is not settled by now it's safe to say it never will be. It really belongs in the class with religion and politics, as just one of those things.

I am not writing this with a view to re-discussing the question. We engineers—for notwithstanding I rejoice in membership in the A.A.A.S. I cannot claim to be a scientist in the professional sense—really have no objection to such re-discussion, but the proponents ought to do what Gibbon advised his critics:—*read* before they try to *write*—so that we may begin at least where we left off; and *then*, if they expect to take any further action than "talk for Buncombe," inform us what they expect to do, or would have us do, about "introducing the metric system." They admit they have—have had for eighty years—a law *legalizing* the metric system, that is, *granting permission* for us to use it; just as if anyone in any nonmetric country needed any one else's "permission" to weigh and measure anything he pleased at any time he pleased and by whatever system or no system he pleased. But that law having failed to achieve their object, and after a century and a half we being no nearer than at the beginning to what they call "adoption," they now seek to make the use of their system *compulsory;* to forbid the process of weighing and/or measuring by any system except their system. Professor Ore now tells us (and it's not the first time we have been told) that "it even appears doubtful whether any compulsory legislation stands any great chance of being passed within the next few years"! Just how much chance does he think there will be of passing such a law in this country in the next hundred or thousand years? And how well will it be enforced if passed? Who wants it passed, anyway? We may answer the last question easily: the same people who put over the French system originally. Professor Ore cites thirteen of them; "the cream of European science," he says, but—all mathematicians and astronomers, not one of whom would be recognized, even in their own country, by the "man on the street" today. As against this lot of starry-eyed philosophers, consider the sort that an American Congress would pick out, the men who do things—Watt, Morse, Westinghouse, Edison, and so on, whom every man on the street knows about. None of such men laid claim to "knowing" either mathematics or astronomy, but any of such would consider themselves, and would be considered by us, as competent to determine the proper size of a pint-pot as the profoundest of intellects. These are the men who have made America great, whose name is gone out into all the earth, and their "gadgets" unto the ends of the world. If any such men ever appeared as the advocate of any law making the transaction of business (at least of their own business) according to some predetermined rule *compulsory*, we haven't heard of it. Any such law would be laughed to death anywhere in America, and I believe Professor Ore would be ashamed to appear in its support.

Since Professor Ore has favored us with a quotation from Secretary Adams' famous report, which he says is a "glowing tribute to the metric system," he should have gone all the way and informed us that in spite of such "glowing tribute" Mr. Adams decided *against* the metric system for America, and the words of his conclusion deserve quotation much more than those cited by Professor Ore: "Were the authority of Congress unquestionably to set aside the whole existing system of metrology, and introduce a new one, it is believed that the French system has not yet attained that perfection which would justify so extraordinary an effort of legislative power at this time" (p. 120).

I need only add that if such an extraordinary effort of legislative power was not justified at *that* time, its justification now—when Anglo-Saxondom is rapidly filling the entire globe and the other nations appear but pygmies alongside it—is infinitely less justified and not to be considered by anyone in his senses.—George Wetmore Colles.

Philosophy in a Nutshell

A philosopher, one Bishop Berkeley,
Remarked, metaphysically, somewhat darkly,
That what we don't see
Cannot possibly be
And the rest is altogether unlarkly.

There was a young man named Kant
Who developed a most extraordinary plant,
A thing out of season
Called the Critique of Pure Reason
Which proved what you can do when you can't.

M. F. Ashley Montagu

A Biologist Reflects Upon Old Age and Death

In his complete and logical rejection of the concept of personal immortality in the last part of his article in The Scientific Monthly (61: 144–149, 1945) Francis B. Sumner expresses, though far more ably than most of us could, the reasoning and conclusions of most of those who have thought at all objectively on the subject, or at least of those who have any sort of background in biology.

Any attempt to separate the destiny of human individuals from that of the rest of the animal kingdom, or, for that matter, the plant kingdom, is bound to collapse as an absurdity if the evidence is examined objectively and unemotionally. That all the phenomena of, and associated with, life, personality, and consciousness are properties of the particular aggregation of matter and energy that is called a living organism can hardly be doubted. Individuality and the great range of apparent intensity of consciousness are merely reflections of the variability and great range of complexity of these organisms.

The characteristic desire for, and belief in, immortality in human beings are easily enough understood as the result of the universal instinct for self-preservation plus the almost equally universal fear of the unknown. These two factors, with usually the addition of the ambition of some persons for control over their fellow persons, are responsible for most if not all of the multiplicity of religions that have characterized the history of all humanity.

In discussing these questions with intelligent nonscientific people, and even with many scientifically minded ones, the same objection almost invariably arises, and it is one which is not disposed of by Dr. Sumner's discussion, at least not in a way that would likely satisfy those who bring it up. This objection is usually worded something like this, "But if there is not an after-life what is the point to everything? What is the justification for all the effort, suffering, and sacrifice of this life? I cannot believe that life, with all its struggle and development, has no meaning."

The hard-boiled scientist might answer, "Why must human life have any more meaning than that of any other of the hundreds of thousands of varieties of life found on the globe? It is all a part of an evolutionary process that got started fortuitously many millions of years ago and has continued since because of certain characteristics in the makeup of living material that make it inevitable that it go on until exterminated by some unfavorable combination of circumstances which may occur on a world-wide scale. No meaning other than this is needed."

From the standpoint of cold logic and such factual evidence as we possess, such a position is probably unassailable. It is, however, from the human point of view, unsatisfactory. With this as the alternative, the ordinary thinking human will either turn to some form of religion or will attempt to drown his despair in hard work, social activity, or drink. Abstract meaning or suggestions of meaning of life as a whole will not suffice. To himself, each person is a very important individual entity and must have a significance manifested in terms of this entity. He is interested in the reason for *his own* existence, not in a faraway impersonal reason for the existence of the universe or of all life. And I dare say that this applies to most scientists, as well as to their colleagues in other, less objective, fields of thought. The number of religious scientists and the amount of speculation and discussion among scientists along these lines is ample evidence of this.

Many years ago while I was still in high school and still active in Sunday-school affairs I ventured to express some of the deep skepticism that I was beginning to feel about much that I was being told in Sunday school and church to a much older friend. Fortunately for me this friend was a very intelligent woman, one who, in spite of being active in church affairs, did her own thinking. To my amazement, her reply on the subject of immortality was, "Of course there is no such thing as life after death. The only immortality that seems possible to me is that of the effect you have on other people while you are alive." As long as I knew this woman she was serene and emotionally well balanced, though unusually active and hard working, in the face of more than an ordinary amount of hardship and misfortune incident to raising a large family.

Her remarks have given direction to much of my own subsequent thinking on the subject.

There seems little doubt that the lasting im-

portance and meaning of a person's life lies in his contribution to the emotional and intellectual richness of human life as a whole. Immortality in the ordinary sense has no place here, but measured in total effect on human life, the contribution made by an outstanding teacher, thinker, or creative mind may even outweigh immortality. Probably few people would demand a further meaning for the lives of Shakespeare, Schubert, or Beethoven than is evident every time their works are read or listened to. The lives of the parents of such individuals certainly do not lack significance, either, nor those of their teachers. One need not search far for the significance of the lives of such men as Galileo, Pasteur, and Darwin Their influence will go on as long as human intellectual life goes on, whether its manifestations are recognized or not.

The above examples are used, not especially because their fame makes them immortal, but because every reader will know who they are and can understand the trend of the argument. If I were to mention one of my early science teachers, a woman who was for twenty years as a high school teacher much more than that, a guiding and molding influence in the lives of a constantly changing but very worth-while group of students, my argument would fall down from lack of familiarity to the reader, not because the example was not significant. This woman aided very materially in stimulating and training minds so they could understand and appreciate the works of the examples mentioned above, as well as doing a lot to make good human beings of her young friends. Significant personalities are usually so because of the composite effect of those with whom they have had contact, especially while young. The person who has exerted such an influence has frequently added materially to the general richness of human life.

It may be objected that, even granting all this, there are untold millions of people whose lives make no imaginable contribution. There are those who are potentially significant but whose lives are rendered sterile by circumstances or environment. There are those whose level of mediocrity is such that they have absolutely nothing to offer. There are also those who die young, those who are insane or feeble-minded, as well as many whose influence is all or largely negative, bad, or destructive.

This is granted. It may be asked in reply, "What significance would immortality have for these people?" I remember seeing somewhere a quotation to the effect that many people are greatly worried about whether or not they will live throughout eternity when they can't even find a way to spend a rainy Saturday afternoon. And what difference would it make whether an idiot were immortal or not? It would merely be prolonging an unfortunate condition indefinitely As for those whose influence is destructive, there seems no reason to doubt that evil effects are just as far-reaching and permanent as good in many cases. The person who destroys, for whatever reason, something that gives emotional satisfaction to others, or who exercises a harmful effect on the minds or characters of his fellow humans may have the satisfaction, if satisfaction it is, of knowing that the evil he does will live on after him. I have noticed that the idea of punishment throughout eternity has apparently had little deterrent effect on most of these.

Waste is characteristic of many of Nature's fundamental processes. Thousands or millions of seeds or eggs may be produced of which only two are likely to become individuals which reach maturity and repeat the process. It neither surprises nor distresses me that there may be many millions of human lives in existence which will have no appreciable significance. The important thing is that in addition there were a Beethoven, a Pasteur, a Darwin, a Benjamin Franklin, an Abraham Lincoln, and the innumerable lesser-known ones who have contributed to the incredibly rich lives we are able to lead today.

To have the opportunity to contribute to the wonderful cultural heritage of humanity should give meaning enough to life for anyone. The quality of the contribution is becoming more and more dependent only on the inclination of the individual and upon his inner potentialities. Leisure and education are no longer restricted to the few.—F. R. FOSBERG.

The Strange Trinity Called Man

The article in the April issue of THE SCIENTIFIC MONTHLY entitled "The Strange Trinity Called Man" should not be allowed to pass unchallenged.

One function of science is to acquire knowledge of the universe in which we live by the methods of observation and experiment; speculation as to those compartments of the universe which science is as yet unable to enter must be left to philosophy. These two functions are equally legitimate and the boundary between them is clearly demarked, but it is subject to continuous readjustment as our fund of scientific knowledge increases.

The position of psychology among the sciences is a peculiar one. The way in which the human mind works is certainly a legitimate object for scientific research, yet psychology is

the offspring not of science but of philosophy, and although in the recent past it has made significant progress in entering the family of the sciences it has not yet forgotten that it is a foster child. Its followers still tend toward speculation rather than experiment, and to assume a dogmatic rather than a ratiocinative attitude. Unlike the savants of science who can test their theories in the laboratory under controlled conditions, each psychologist is free to formulate his own peculiar beliefs which he can maintain against the claims of others, because there is as yet no method by which the values of rival theories may be reduced to a common denominator.

The article referred to is characterized by many statements of this sort which are capable of neither proof nor disproof, and not a few of them appear to be inconsistent with the facts. Among the latter is the statement that conventional psychology has always concerned itself with the conscious, and that psychoanalysis has recognized that human personality is like an iceberg, the bulk of which is submerged beneath the surface. As a matter of fact, however, the iceberg simile is far older than psychoanalysis, it having been used by that most classical of all students of psychology, William James. Further, it seems somewhat inappropriate to the psychoanalytic school of thought, which, to be consistent should logically require not less than three icebergs, two supported by surface tension and the third completely sunk.

The use of the term "id" is also to be deprecated. It was originated by August Weissmann for use in cytology and its later application to an entirely different object cannot but result in confusion, especially so because its use in psychology applies to a conception for which a universally understood term has long been in use—it is the subliminal self arrayed in fancy modernistic nomenclatorial garb.

The author's theory that composers give numbers to their compositions rather than names because they themselves do not understand the full import of their productions seems scarcely tenable. Mendelssohn, writing to Souchay, explained that he gave no names to his "songs without words" (the names by which these compositions are popularly known were given at a later date by Stephen Heller) not because the thoughts which evoked them were too indefinite to be expressed in definite language, but that they were too definite to be expressed in indefinite language. Tschaikowsky called his sixth symphony "program music," but said that its program was too intimate and personal to be shared with the public, and nobody knows what prompted Beethoven to remark *"So klopft die Schicksal an der Pforte"* just when he did.

That suicide may frequently result from intrapsychic strain is very probable, but the interpretations which the author gives of certain instances from life and literature are not always easy to follow. For instance, the case of Javert in Victor Hugo's novel is in point. One would think that the conscientious superego would have striven to protect Jean Valjean while the selfish ego and the irresponsible libido were clamoring for his destruction, and there is no apparent reason for the author's preference for an alternative interpretation.

When the author ascribes phallic significance to the Trylon and Perisphere at the New York exposition he appears to be doing violence to that fundamental unifying principle which underlies both science and philosophy, known as William of Ockham's razor. The explanation offered by the architect is simpler and more reasonable and in the absence of evidence to the contrary should be accepted. If these objects really had phallic significance, why were there not two perispheres? Would the author attribute phallic significance to the ice-cream cone, which is of the same shape as the Trylon, or the scoopful of ice cream which fills it and which in form resembles the Perisphere?

Finally the naive way in which this author has swallowed the ancient Mather-Penn hoax hook, line, and sinker is a real cause for astonishment. Further, the version of the letter used in the article here under discussion shows signs of having been expurgated. The more familiar form is characterized by a peculiar orthography which scholars tell us was characteristic of the eighteenth century, but not of the seventeenth.

One wonders if an author who accepts as true so many errors which can be so easily detected, in discussing a matter so well understood by everyone, can be trusted in those statements which he makes concerning matters on which authorities generally disagree and which cannot be subjected to any experimental test to verify or discredit them. If the blind lead the blind, shall they not both fall into the ditch?—JOSHUA L. BAILEY, JR.

The Strange Trinity Called Man

The editor's challenge to "come forward with contributions as clear and interesting" as Mr. Boyajian's essay on psychoanalysis sounds fair enough. In fact, it is not. Science, even popular science of the best sort, can seldom compete with literature. There is drama in scientific research for those engaged therein; it is indeed rare to be able to convey it to others.

The Freudian psychology, on the other hand, is almost straight drama. "Human personality, then, consists of these three persons: Ego,

Superego, and Libido. Conflicts within the trinity are eased by dulling the *censorious* partners and 'releasing' the Libido. At night the Ego sleeps much more deeply than the other two. The Libido takes advantage of the drowsy Ego and enacts its hopes in dramatic scenes.'' Thus Boyajian. Of course it is interesting. It has everything the playwright has used since the times of Aeschylus.

But is it science? Is it good popularization of science? Metaphor, simile, personification—these have their place *in* science, but they must never be mistaken *for* science. Most of psychoanalysis consists in attempting to elevate elaborate metaphors into scientific generalizations. It is interesting all right.

The editor, however, also calls Mr. Boyajian's essay ''clear.'' Here one must dissent. For clarity means much more than using familiar words in a sound rhetorical pattern. Clarity means pointing unambiguously at a particular thing. Take almost any of his sentences at random and ask yourself what are the actual referents. ''Subconscious workings of sexual energy.'' Try it. There is, of course, an actual ''sexual energy''—the whole activity of the sexual apparatus. But this is precisely not what the analyst is talking about. For him a complete hysterectomy may increase the ''sexual energy.'' What then is the sexual energy? What specifically is the referent of ''subconscious?'' Just what is meant by the interesting metaphor that a ''malfunctioning'' Superego may tend to *choke* the Libido? To call attention to a scientific principle by means of such a figure of speech would be magnificent; to substitute its vivid vagueness for the facts is mere verbal magic or legerdemain.

It was quite a task to rid natural science of demons, animal spirits, and all the other personifications of natural phenomena. We have almost completely succeeded. In the much contemned ''academic psychology,'' also, victory is close at hand. Even the more thoughtful of Freud's disciples recognize that the time for dramaturgy has passed.

Freud called attention to relatively neglected problems and by intuitive genius of the highest order discerned important principles concerning the motivation of human behavior. Perhaps it was right to set these forth first in the highly dramatic form he adopted: he got attention. Today a major task is to restate these principles so that they will have *clear* and unambiguous reference to concrete facts. That task will only be hindered by such flamboyant dramatization as we find in ''The Strange Trinity Called Man.''—Horace B. English.

The Strange Trinity Called Man

We are obliged to Paul W. Holloway for so promptly furnishing us an authentic letter to replace the unauthentic Cotton Mather letter mentioned in my article in the April 1946 SM.

One does not have to be a psychoanalyst to discern the poorly concealed murderous thoughts that this fundamentalist harbors against modernists, just as another Paul did before him against those who disagreed with him first on Mosaic law and later on Christian dogma. Paul Holloway would like to see all such as myself strangled, and, while he does not openly threaten to do it himself, he suggests that we hang ourselves and that I ''do it quickly''—he cannot wait for it!

One trouble with fundamentalists like Mr. Holloway is that they have absorbed neither the spirit of science nor that of Christianity. Worshiping Christ as King or even doing miracles in his name does not make one Christian (Matt. 7: 21–23); neither does collecting observations of physical phenomena make one a scientist (as Mr. Holloway implies in his letter). More than once Christ got away from a crowd that wanted to make him its King (John 6: 15, 22–26), while he welcomed an inquiring scholar of his day, by the name of Nicodemus, to sit down and talk it over with him, even though their understanding of the truth about man and God did not exactly agree.

The fundamentalists are afraid that the modernistic scientists want to discredit the Bible and overthrow Christianity. How foolish. This writer loves the Bible and thinks it is the most beautiful book: Greek and Roman classics are not to be compared with it. He has taught both adult and young Sunday School classes and believes in inspiration—that God speaks to man, to all men, and not only to St. Paul—even to Paul Holloway (if he would but listen to him!). Because the writer believes in inspiration, he is tremendously interested in learning its *modus operandi*. He believes that God is not an outsider to us but immanent in us: or, as others have said it, ''We live and move and have our being in Him.'' All our creative impulses (artistic, social, industrial) and all our urges to discover the truth (scientific, religious, philosophical) are the normal workings of that divinity in us.

Surely, the Kingdom of God is within us; and those that worship him shall worship him neither on this mountain, nor in Jerusalem, nor yet in Mr. Holloway's traditionalist and murderous Sunday School, but in Christian spirit and in scientific truth.—A. Boyajian.

This is the last word on The Strange Trinity Called Man.—Ed.

Humanism

In a letter in the SM for April 1946 Mr. Harold Rafton states that "from any objective modern standpoint it must be conceded that the moral content of religions is the only lasting contribution that they have made to man's advancement." Mr. Rafton suggests that Christians and Jews should scrap "all supernatural, traditional, and folkway elements of their Faiths" and unite their identical moral codes because this would solve the "Jewish problem" and would bring both sets of religious ideas "squarely in line with current scientific knowledge." The letter is very nearly as naive and uninformed as the article (in the same issue) on Humanism by Dr. Archie J. Bahm.

In support of this contention I offer the following: from one of the most objective modern standpoints (that of A. J. Toynbee in *A Study of History*) it is demonstrated, by historical analysis, that the contribution of religions has been much more than the moral content alone: several religions have furnished the social institutions and organizations within which several civilizations have come into being. There are, of course, several other standpoints, but it is necessary to mention only one. (It may be, of course, that Mr. Rafton would not regard this as "a lasting contribution to man's advancement"; I am not sure. But if he would not so regard this contribution, then it would be difficult to imagine what he would define as a lasting contribution.) This is uninformed.

The suggestion that Christians and Jews should scrap all but the ethical elements of their faiths is naive (in the specific dictionary sense of "foolishly simple") because, "from any objective modern standpoint," it would not only be impossible but would achieve none of the results described by Mr. Rafton. It often happens that the individual who is committed to one set of superstitions is likely to regard all opinions other than his own as superstitions. It is obvious that Mr. Rafton is deeply committed to the current superstitions about "objective standpoints," the supremacy of "modern science," "rationalism" and—perhaps the callowest of all—"humanism" (in the Bahm sense).—E. D. MYERS.

Humanism

Kindly permit a comment on the article "Humanism" by Archie J. Bahm (April SM); first column, second paragraph: "Science deals with facts and religion with values."

Science does not always deal with facts—it has often instead dealt with what the scientist believed to be facts. What science there was once dealt with a flat world, not a fact. Within a lifetime science considered the atom a single indivisible ultimate unit of matter, not a fact. One can greatly multiply such a list Science dealt with them as facts, and they were not facts. Such "facts" have been proved by scientists themselves not to be facts. They were beliefs—science believed them to be facts.

Now we have new "facts," in their stead, that we believe to be true facts. There can be no ultimate proof of a fact because it is at least conceivable that some thought or action may depose the same fact and supply a new fact in which we anew believe. Also a fact is a value and a value may be a fact.

Science then depends on a belief in changing facts and on facts that it believes will never change. Science then depends on belief. Religion depends on belief. If the individual did not believe in his religion, he would have no religion.

They both seem to depend on belief and seem not to know it (belief) as a mutual unity.—WILLIAM F. HOWARD, M.D.

Mildly Critical

Doubtless conforming to a spirit of emulation without envy, published failures to devise a good modern unified theory of an assumed materialistic universe relate largely to mathematical experimentation of a trial and error nature. These attempts seem foredoomed to continued failure for very cogent reasons, a few of which are cited.

First: Because it is known that one cannot get more out of mathematics than is put into it.

Second: Because of the fact that, on the materialistic assumption of individually unrelated and non-associated "particles," it is logically necessary to produce entirely separate and independent hypotheses for each and every one.

Third: For the reason that in all materialistic hypotheses there is complete failure to provide mathematical justification for the one exception proposed in the laws of chance, namely, the exception claimed of series of virtually infinite perfect coincidences, as a matter of chance, of practically infinite independent and unrelated recurrence of discrete, identical conditions, without a single known throw-off.

Fourth: No provision is made for the long term *maintenance* of matter and energy.

Fifth: Mathematicians and physicists, in their equations, ignore life and its phenomena. These must be consistently included in any workable unified theory of the known universe.—CHESTER B. DURYEA.

THE BROWNSTONE TOWER

ONE day when I was a boy my chum and I sat on the fence of an automobile track while cars were warming up for a race. To our surprise one car pulled up in front of us, and the driver with a grin shouted, "How'm I doin'?" We assured him with enthusiasm that he was doing fine. But in the race that followed he brought up the rear. Since then I have tried to get facts before answering the question: How'm I doin'? I am asking that question now with reference to the SM. Are we covering the field of science with articles properly distributed among the chief branches? If not, what adjustments should we attempt to make? To determine coverage I have classified by sections of the A.A.A.S. the subject matter of 258 principal articles which appeared in volumes 58 to 62 during my editorship. The results are expressed in percentages in Table 1. For comparison I list also in percent the distribution among sections of members who take the SM. The last column shows the difference between percentage of articles and percentage of members in the several sections.

Because many articles of opinion, which I call "wisdom," do not strictly apply to any particular section of the Association, I have classified them under Section K or L, because they have to do with scientists or the philosophy of science. The high percentage of contributions in these sections should therefore be discounted. Many other articles overlap two or more sections. These have been assigned to the section that seemed predominant. Because of these uncertainties another person might have arrived at a somewhat different set of figures. It is probable, however, that anyone would be struck by the relatively small percentage of articles in physics and chemistry, particularly the latter. No doubt contributions in these fields are infrequent because it is difficult to write informatively about highly technical subjects. Chemists, who are the most numerous readers of the SM, should recognize this deficiency and try to overcome it. Deficiencies more difficult to explain are also present in psychology, engineering, and medicine. In these subjects it should be possible to obtain large numbers of sound popular articles. In geography and zoology an excess is apparent.

TABLE 1

PERCENTAGE DISTRIBUTION OF SM ARTICLES AND MEMBERS BY A.A.A.S. SECTIONS

	Section	*Articles*	*Members*	*Difference*
A.	Mathematics	2.7	4.4	− 1.7
B.	Physics	4.6	8.7	− 4.1
C.	Chemistry	3.9	18.0	−14.1
D.	Astronomy	2.3	1.7	+ .6
E.	Geology and Geography	12.4	5.9	+ 6.5
F.	Zoological Sciences	13.6	8.4	+ 5.2
G.	Botanical Sciences	5 8	5.0	+ .8
H.	Anthropology	2.7	1.9	+ .8
I.	Psychology	3.5	6.2	− 2.7
K.	Social and Economic Sciences	13.6	3.5	+10.1
L.	Historical and Philological Sciences	12.0	1.8	+10.2
M.	Engineering	3.9	10.6	− 6.7
N.	Medical Sciences	7.4	17.0	− 9.6
O.	Agriculture	7.0	3.4	+ 3.6
Q.	Education	4.6	3.5	+ 1.1

Other subjects seem to be properly represented in proportion to membership by sections.

It may be instructive to classify our principal articles in other ways. For example, I find that 5 percent of the 258 articles are primarily biographical; 12.4 percent are chiefly historical; 29.8 percent are essays of "wisdom"; and the remainder, 52.8 percent, are primarily factual, having been written for the purpose of describing and explaining the present status of various scientific subjects. Whether this is a satisfactory distribution can be determined only by the readers.

Articles on the physical sciences, including geology, constitute 23.6 percent of the total; those on the biological sciences, including medicine, 33.7 percent; and the remainder, including the "wisdom," (42.7 percent) may be assigned to the social sciences. This simple classification points again to the deficiency of articles in physics, chemistry, and engineering.

The foregoing classifications give no information about the quality of articles published in the past five volumes. Like the contents of any other magazine, those of the SM can be improved. This can be most readily accomplished by accelerating the influx of new manuscripts, thus giving the editor a larger number from which to select the best. Perhaps potential contributors should be reminded that they need not wait for a personal invitation from the editor to write for the SM. Unsolicited manuscripts are just as welcome and are given just as careful attention as those that are solicited.

The quality of the contents of the SM can also be improved by increasing the membership of the Association. With greater resources behind the SM, the personnel of the editorial office might be increased, and authors might be paid for their efforts in cash as well as in reprints. With more help the editor could spend more time in soliciting and evaluating manuscripts, more effort could be devoted to revising and checking the contents of manuscripts, and color printing might become standard practice. If every reader of the SM would undertake to secure a new member for the Association, some of our dreams for a better SM might come true.

The third column in Table 1 should be examined by those who are planning to write for the SM or who may be desirous of placing an unpublished address. Note that more than half of the readers of the SM are physicists, chemists, engineers, and physicians, and that no field of science is unrepresented among the readership. Therefore, every article published in the SM should be interesting and intelligible to people of diverse training and experience. Recently we received the manuscript of an excellent address to a botanical audience. The author wanted it to appear in the SM in order to reach a large number of botanists. If he had known that 95 percent of the readers of the SM are not botanists, he would have sought publication in a botanical journal.

Old Hi Ho and young Ho Hum intend to debate the question whether articles for the SM should be written to please the readers or to please the authors. The editor will not be influenced by their harangue, however persuasive. With him readers come first, authors second.

F. L. Campbell

THE SCIENTIFIC MONTHLY

SEPTEMBER 1946

THE DETERIORATION OF MATERIEL IN THE TROPICS*

By W. G. HUTCHINSON
DEPARTMENT OF BOTANY, UNIVERSITY OF PENNSYLVANIA

IN SPITE of considerable experience in the use of military equipment in the Philippine Islands and in the Panama Canal Zone the United States approached World War II surprisingly unprepared to carry on any military engagements in the humid tropics. Some of our Allies were equally unprepared in spite of even longer experience in tropical areas. Consequently, enormous quantities of equipment of all kinds which had been produced for use in temperate climates were sent to humid tropical areas with little, if any, thought of its survival under the devastating conditions of high humidity and other factors which make up a tropical environment. As a result, enormous losses were experienced in many different categories of military materials. Textiles and textile products were rapidly weakened and disintegrated by the action of cellulose-destroying fungi and bacteria. In an environment in which the relative humidity might almost continuously be 90 percent or more, such organisms grew in practically unrestricted fashion. In various types of electrical equipment extensive growth of molds was common on hook-up wires and on terminal blocks. Such growth was often accompanied by failure of the instrument. In optical instruments which were satisfactorily sealed for efficient operation in a temperate climate the inner glass surfaces of prisms and lenses became so overgrown with fungi, which brought about an etching of glass, that the instruments required careful overhauling in the field or, in many instances, had to be discarded and replaced by new instruments. Cork gaskets, shock pads, etc., disintegrated relatively quickly under the influence of mold and bacterial growth. Equipment consisting entirely or in part of leather was very heavily overgrown by mold of several types. The stitching in such equipment was often readily destroyed by cellulose-destroying organisms so that the equipment might fail to hold together. Photographic films became badly fungus-

* This paper is based upon studies made at the University of Pennsylvania and in the Panama Canal Zone under Contract OEM-sr-205 with the Office of Scientific Research and Development. At first under the direction of Section 16.1, this Contract was later transferred to the Tropical Deterioration Administrative Committee. Various aspects of the work have been conducted in collaboration with the following subcommittees: Coordination of Test Methods; Optical Instruments; Electrical and Electronic Equipment; Photographic Equipment and Supplies; Synthetic Resins, Plastics and Plasticizers; and Textiles and Cordage. Microfilm copies of the *Official Summary Technical Report* of the over-all activities of the Tropical Deterioration Administrative Committee can be obtained from the Office of the Publications Board, Department of Commerce, Washington 25, D. C.

spotted during storage even though precautions were taken in such storage to prevent high temperatures and excessively high humidities. Wood and wood products, including paper, were also subject to severe attack by microorganisms.

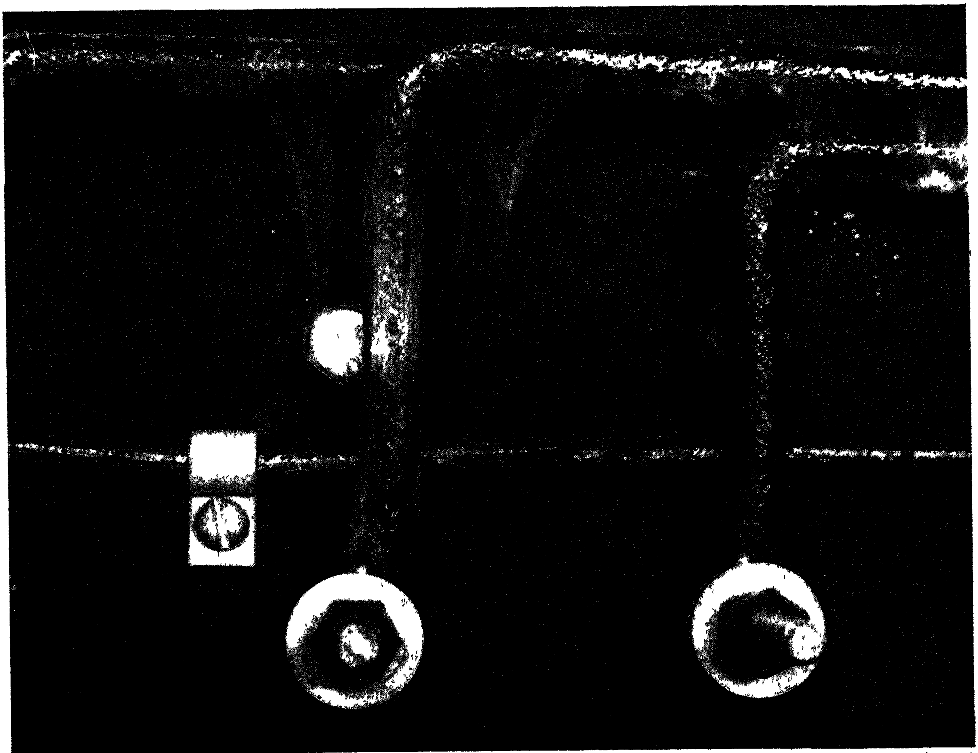
Although this paper is concerned with the activities of fungus or bacterial organisms in inducing deterioration, it should be pointed out that in a tropical environment materials may be subjected to other deleterious effects. Metallic corrosion is an ever-present problem in warm, humid areas. Termites present especially serious problems in connection with wood and wood products. Photochemical disintegration becomes important in textile deterioration. High humidity and accompanying condensation may have serious effects upon the operation of electric and electronic equipment.

It must be borne in mind that such deterioration as cited above is not general in all tropical areas but is confined to the humid tropics. It may be said that the humid tropics are characterized climatically by a consistently high relative humidity, a relatively high temperature, a narrow range of temperature, a relatively high rainfall or a consistent distribution throughout the year of a moderate rainfall, and, finally, lack of excessive drying winds. Such variation in one or more of these climatic factors may occur within relatively small areas that the extent of deterioration may be consequently very variable. For instance, in New Guinea, where great loss of materials by fungus and bacterial deterioration was experienced, there are certain areas which cannot be said to be characteristic of the humid tropics and in which little, if any, deterioration occurred. It is of course unsafe to postulate that an area which receives heavy rainfall must be an area in which deterioration will be experienced. Heavy rainfall may be followed by drying winds to such an extent that the area may be relatively free from difficulty while, on the other hand, an area in which the rainfall is relatively light may have such a distribution of this rainfall throughout the year that the area may be particularly noteworthy as a region of excessive deterioration.

A "dry season," which may occur during some portion of the year in the humid tropics, may be characterized by light rain or almost entire lack of rain, sometimes by drying winds and consequently by a much lowered relative humidity. During this season many of the tropical trees lose their leaves, the soil may become dried and cracked, and much of the vegetation becomes brown and dry. During such periods deterioration is much less rapid or may be entirely absent as equipment may become well dried out. However, in some tropical areas, even during the dry season, relative humidity may remain very high, especially at night, and there may be such heavy condensation in the early morning that equipment will be thoroughly wetted. Optical instruments may show initiation of infection during such dry periods.

The observation has been made repeatedly that certain types of equipment which have dried to the point of cracking or checking during the dry season may become especially susceptible to fungus attack with the onset of the wet season. A climate in which wet and dry seasons alternate may therefore be a more detrimental one for some equipment than a climate in which there is a continuous high humidity. Plywood, for instance, may remain relatively free from fungus damage during months of wet weather. After drying during the dry season, however, it may become badly deteriorated as moisture increases with the advent of the following wet season.

A brief résumé of the problem of deterioration as it affects different classes of materials is presented in the following sections together with some possible measures of control. No attempt is made



Special Engineering Section, Panama Canal Department

FIG. 1. CABLE-LIKE GROWTH OF FUNGI IN A TRANSFORMER

SUCH GROWTH, OCCCURRING ON UNTREATED COTTON-BRAID HOOK-UP WIRES, MAY CAUSE A SHORT CIRCUIT.

here to summarize all control methods; particularly those which have been found effective in the experience of the author are considered.

Electrical Instruments. Much electrical and electronic equipment prepared for use within the territorial United States has proved completely unserviceable after a short period of use or storage in humid tropical areas. Frequently such equipment has shown heavy mold development, especially on hook-up wires and terminal blocks. Although it is possible that functional failure may be primarily associated with moisture rather than directly with the mold, it is certain that a heavy fungus fringe on a hook-up wire will retain moisture which might otherwise evaporate. To the operation man in the field the mere presence of a mass of mold within his instrument is indicative of trouble.

Under certain conditions, fungus development within electrical and electronic instruments may become sufficiently extensive to form cable-like extensions which may bridge from one wire or terminal to another and thus may conceivably be responsible for shorting. Figure 1 represents a situation of this sort in a transformer in the Panama Canal Zone.

Fungi which have most commonly been found associated with hook-up wires in humid tropical areas are species of *Aspergillus, Monilia, Mucor, Penicillium, Rhizopus*, and *Trichoderma*.

In an attempt to control the development of fungi within electrical equipment, several remedial measures have been tried. A varnish or lacquer has

een sprayed over hook-up wires and erminal blocks, or over the entire asembled equipment after masking certain ritical parts. While probably no varnish or lacquer is completely moistureproof, the application of such a substance does tend to keep various parts of he equipment relatively dry. However, some of these varnishes and lacquers will, of themselves, support mold growth. For this reason, much work has been done on the incorporation of effective fungicides into lacquers and varnishes. Various branches of the services have been so stringent in their requirements for clean electrical equipment that they have specified that no hook-up wire shall be acceptable if it is able to support any fungus growth. To meet this specification it has been necessary for manufacturers to add some fungicidal material to the lacquer or varnish. Those which have been found most successful for this purpose are salicylanilide and pentachlorophenol. A number of the organic mercury compounds are very effective fungicides, but their use has been discouraged because it is reported that they may produce damage in selenium rectifiers.

A remedial measure that has proved very effective is the substitution of some material which does not support fungus growth for the cotton braid so often used in wrapping hook-up wires. Glass braid, asbestos, cellulose acetate, and various synthetic fibers and plastics have been used for this purpose with considerable success. However, many of these materials have presented production problems which could not well be met during the stress of wartime conditions.

A method of controlling fungus development within electrical equipment which has been found highly effective in the field is the generation of heat within the instrument sufficient to keep the temperature inside the instrument above that of the ambient temperature so that condensation will not occur on hook-up wires and other parts of the equipment. In other cases the equipment has been kept relatively dry by constant forced ventilation.

Optical Instruments. It has been known for many years that the glass surfaces of optical instruments kept in tropical regions are subject to deterioration from the formation of cloudy and splotchy films or granular incrustations, due to leaching or other chemical or physical phenomena, and filamentous tracery, resulting from mold growth on the glass surface. This surface "tarnishing" may appear on new or freshly cleaned optical elements after one to six months in the tropics. While reports of such damage have been common throughout all humid tropical regions, particularly heavy damage had been recorded prior to the recent war from the Canal Zone, Malaya, and the Philippines. Recent reports indicate that there has been severe damage to optical instruments throughout extensive areas of the Pacific war theaters.

Fouled optical glass may interfere with the efficient operation of an instrument in two ways: (1) If the affected area is on some internal part, such as a reticle which is continually in focus, there may be sufficient interference and loss of light to impair greatly the usefulness of the instrument. Such instruments must be sent to a repair shop for cleaning. A fungus spot on the reticle of a director telescope has been seen to block vision so competely that it was impossible to follow the course of an approaching plane. In Figure 2 is shown a spot of tangled fungus growth on a reticle surface which could cause considerable interference with vision. (2) If optical parts are allowed to remain without cleaning, permanent damage may result from the etching of the glass surfaces, which must then either be repolished or the elements replaced. The trouble and expense of the cleaning and

replacing of damaged optical elements together with the fact that essential optical instruments may be out of service from time to time and ultimately show a considerably shortened life have made it an urgent necessity to find methods for eliminating, or at least retarding, this damage.

Sealed optical instruments may become fungus-infested on the internal glass surfaces by direct fungus invasion of the instrument or by introduction of fungus spores there by small animal vectors. Dr. Frank L. Jones,[2] Chairman of the Sub-Committee on Optical Instruments, has pointed out that mites are almost always found within fouled instruments returned from the tropics for cleaning and repair. Figure 3 shows a dead mite on the surface of a binocular reticle with fungus filaments arising from its body. Fungus spores provided with such organic nutrient as a mite body, mite feces, dead fungus filaments or spores, microscopic fragments of cork, wax, or other detritus may germinate in condensed moisture and form a

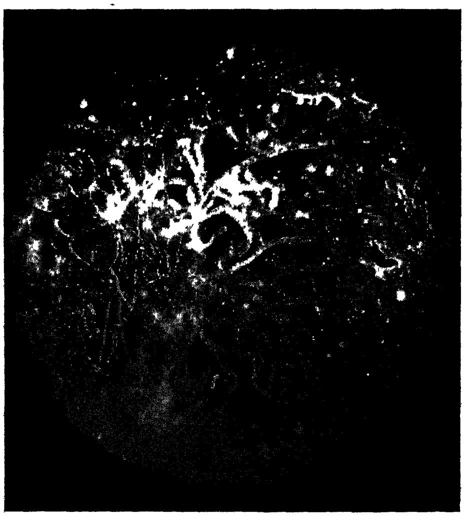


FIG. 2. FUNGUS–FOULED RETICLE
DARK-FIELD PHOTOMICROGRAPH OF FUNGUS GROWTH ON A RETICLE FROM A BINOCULAR IN THE CANAL ZONE. NOTE "FROSTING" OF GLASS WHICH ACCOMPANIES GROWTH OF FUNGUS FILAMENTS. (×50).

FIG. 3. MITE AND FUNGUS
A GROWTH OF FUNGUS FILAMENTS FROM THE DEAD BODY OF A MITE ON THE RETICLE OF A BINOCULAR. SPECIMEN FROM THE PANAMA CANAL ZONE. (×80).

radiating fungus spot upon the glass. There is no evidence that the fungus obtains any mineral nutrients from the glass itself. That fungus-fouling is not necessarily dependent upon mite infestation is shown by Figure 4. Chemically clean glass was inoculated with masses of fungus spores. The spots shown here developed from the growth of certain spores which apparently secured their nutrient from masses of ungerminated, partially lysed spores.

A filamentous tracery of relatively deep etching may develop upon glass surfaces which have long been overgrown with fungus mycelium. Although no precise data are available on the mechanism of such etching, it is probable that the water film surrounding each fungus filament promotes leaching of some of the glass constituents. That some of the excreted fungus metabolites may hasten such leaching may only be surmised until evidence is obtained.

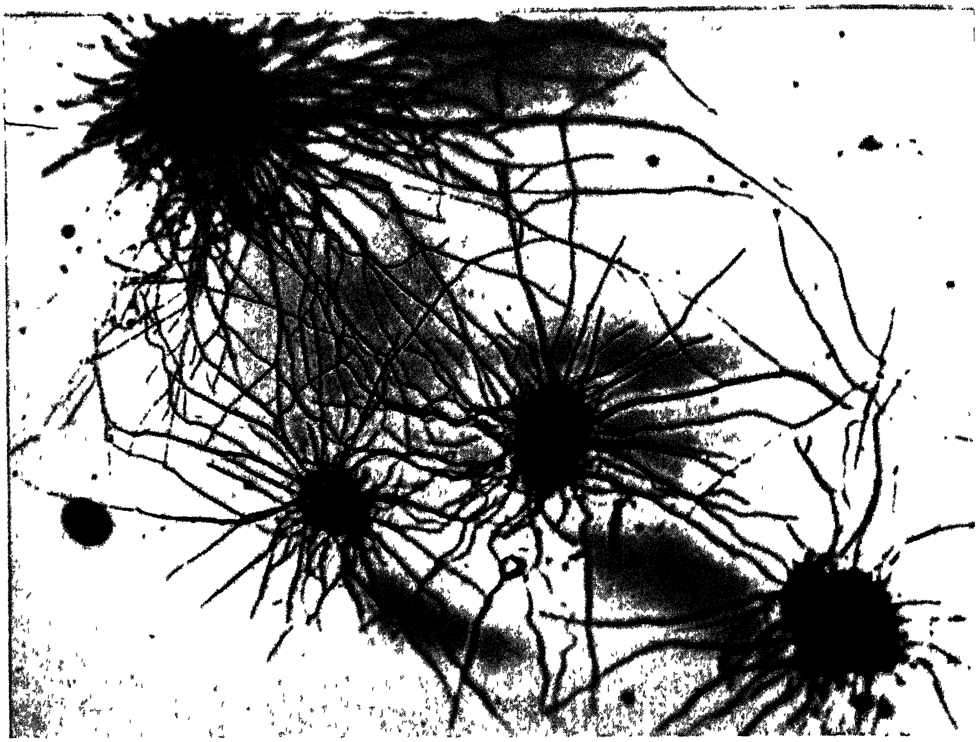


FIG. 4. FILAMENTS RADIATING FROM SPORE MASSES ON GLASS
PRODUCED BY SPRINKLING SPORES ON CLEAN GLASS AND INCUBATING AT A HIGH HUMIDITY. (×50).

The fungi associated with this fouling of optical surfaces are not of any unusual sort but are common, widely distributed molds. *Monilia crassa* and several species of *Aspergillus* and *Penicillium* have most commonly been isolated from glass in the Panama Canal Zone. All of these may be seen sporulating on the optical surfaces.

Binoculars and other optical equipment of recent design may be so well sealed that the penetration of fungi or their vectors may be impossible. However, many thousands of optical instruments used in tropical regions during the war were not so sealed. It has been found possible to prevent the development of fungi within such instruments by the use of a volatile fungicide. Metacresyl acetate, known commercially as cresatin, incorporated into an ethyl cellulose base, may be placed into small metal capsules from which it will evaporate very slowly. These may be fastened to the inner surfaces of optical equipment, safely out of the path of light. One such capsule per chamber has kept binoculars free from mold growth for as long as two years. Sodium ethyl mercury thiosalicylate, or merthiolate, has been used on aerial cameras with success by the Australians in preventing fungus encroachment upon the lenses.

Proper storage of cameras, microscopes, and other optical equipment will effectively prevent fungus fouling.

Cork. Various materials composed of cork may be seriously damaged by the action of microorganisms. The cork pads so often used in optical equipment serve as a source of nutrient for fungi, which may spread extensively over glass surfaces from the infected cork. The cork

lining of aerial camera cones has supported such luxuriant fungus growth that much of the instrument might be overgrown with mold or showered with mold spores.

The impregnation of cork with 2 percent paranitrophenol dissolved in amyl acetate has kept cork free from attack by molds for an exposure period of six months in the Canal Zone, whereas untreated samples became heavily overgrown in three to five days Similarly treated samples have remained clean in the tropical house at the University of Pennsylvania for fifteen months.

Plastics. Modern plastics have found important uses in many types of military equipment. As vital parts of electrical or optical equipment and as substitutes for leather, cork, wood, and metal in many service materials, plastics have been subjected to the deleterious effects of the humid tropics. Under the influence of moisture and microbiological activity these plastics have suffered various damage. Some of the laminated plastics have developed checking and separation of components. Plastic surfaces have become crazed, blistered, or whitened. Certain types of plastics have developed extensive molding. Figure 5 illustrates a plastic terminal block from a transformer in the Panama Canal Zone with mold growth over much of its surface Such mold growth may result in the etching of the plastic surface, may have some effect upon the electrical resistance of constituents of electrical and electronic equipment, or may cause severe reduction in light transmission when a sheet plastic is used as an instrument window.

A variety of fungi are encountered in association with plastics. Laminated plastics may be attacked by such cellulose-decomposing organisms as *Chaetomium, Curvularia, Memnoniella,* or *Metarrhizium.* Several species of *Aspergillus* and *Penicillium*, especially *A. chevalieri* and *P. luteum*, have been isolated from infected plastics in the tropics.

Special Engineering Section, Panama Canal Department

FIG. 5. FUNGUS GROWTH ON A PLASTIC TERMINAL BLOCK

Plastics that have been shown to be resistant to fungus growth should be chosen for tropical use. Little has as yet been done to develop fungicidal or fungistatic plastic surfaces by the incorporation of fungus poisons into plastics.

Photographic Film. The deterioration of photographic film in the humid tropics, resulting from fungus attack and moisture, is a problem which has been recognized wherever photographic work has been done under tropical conditions. The recent war has high-lighted this problem because of the great loss that has been experienced not only in unexposed film in rolls, packs, and packages but also in the exposed and developed film negatives which have been filed and stored for reference. A tropical packaging of films was developed which has been very effective in preventing loss of unprocessed film. Stored processed film, however, has presented a difficult problem. These stored negatives often became spotted with numerous deep blue patches which have the general outline of fungus colonies. Figure 6 shows a photograph of such a spotted negative. Printing by projection from negatives spotted in this manner results in white or light-colored areas on the print in regions where the blue spotting appeared on the negative. This particular condition has been noted only on the backing of those film materials which have a blue dye incorporated in the antihalation coating. The mycelia growing on the emulsion surface of such film are not associated with any color change. A less striking but even more serious phase of microbiological deterioration is the etching of the surfaces of the negative by microorganisms.

FIG. 6. FUNGUS SPOTTING ON A NEGATIVE

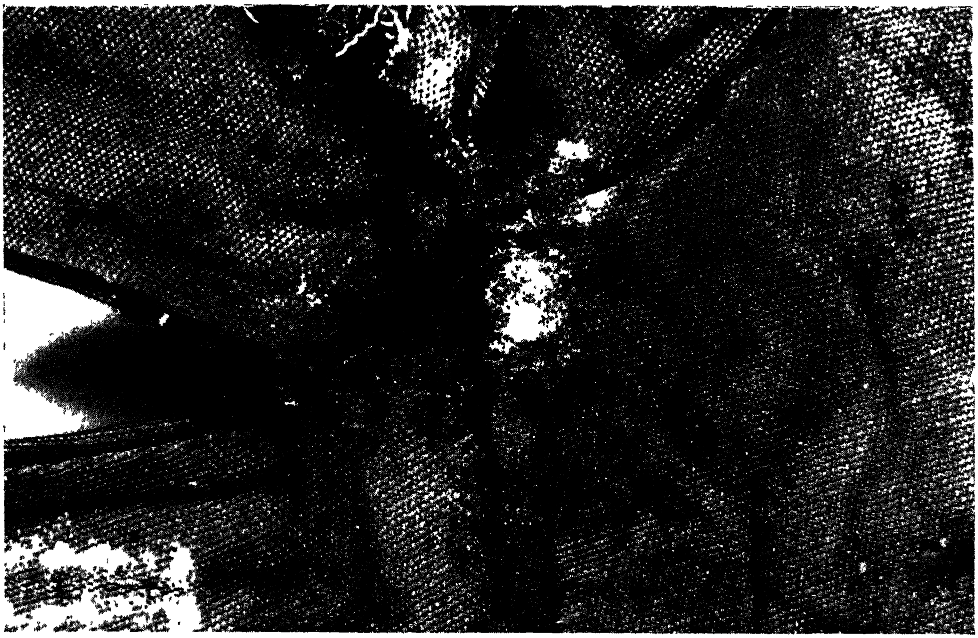


FIG. 7. PORTION OF LAPEL OF COTTON FIELD JACKET
DOTTED WITH FRUITING STRUCTURES OF *Chaetomium globosum*, SEVERAL SUCH JACKETS, THOUGH NEVER ISSUED, HAD DETERIORATED DURING STORAGE IN A WAREHOUSE ON BIAK ISLAND. PHOTO (×2) BY COURTESY DR W. L. WHITE AND PHOTOGRAPHIC DEPARTMENT, PHILADELPHIA QUARTERMASTER DEPOT.

It has been found possible to prevent fungus deterioration of processed photographic negatives by use of one of the commercial quaternary ammonium compounds. Roccal (high molecular alkyl-dimethyl-benzyl-ammonium chlorides) in a dilution of 1 part of the commercial solution in 10 parts of water makes a fungicidal bath into which films may be momentarily dipped. Such treated films have remained free of fungus attack under simulated tropical exposure in the Tropical House at the University of Pennsylvania for more than 5 months. Untreated film has developed fungus spotting within two weeks. Tests performed by one of the well-known manufacturers of films have shown that no detrimental effects to the film occur with a Roccal dilution of 1 part in 10 parts of water.

Textiles. Various types of textile products may be degraded by microorganisms. Fungi may live on the surface of the textile, gaining nutrition primarily from the sizing of the cloth and other fortuitous nutrients and present a superficial "mildewed" appearance. Molds of this sort may not cause any important disintegration of the fibers but are undesirable because of spotting and odors which they produce. The Australians have reported that some of the superficial molds may attack the water-repellent finish of the cloth so that the fabric becomes available for attack by the cellulose-destroying organisms. A number of fungi and bacteria may derive their nutrition directly from the cellulose or other basic constituent of the textile fiber and in this way bring about a fundamental breakdown of the fibers themselves with consequent disintegration of the cloth or other product (Fig. 7).

One is sometimes reminded that if equipment is kept dry in the tropics there will be no problem of deterioration

ıe to fungi and bacteria. In the case ' textiles, as perhaps in no other type ' equipment, it becomes completely im- ɔssible to maintain dryness, for many ːxtile products are used primarily to ɜep other materials dry. Canvas tents, ɪrpaulins, canvas covers for fire control ɋuipment, etc., must be exposed directly) the elements to fulfill their intended urpose. Such materials are thus sub- ɜcted to deterioration not only as a re- ılt of attack by microorganisms but lso that brought about by exposure to unlight and alternate wetting and dry- ıg.

The problem of treating textiles be- omes a complex one indeed when one ealizes that in addition to the necessity f impregnating the material with some ungus inhibitor it is essential also to ıake the cloth water-repellent and often- imes fireproof as well.

The Quartermaster program of re- earch on textile deterioration with its ːmphasis on investigation in tropical ɪreas is a commendable one.

Tropical Storage. Military ware- ıouses in permanent tropical installa- ːions are commonly equipped with air ɔonditioning. In some instances, how- ɜver, air conditioning has been assumed to mean raising the temperature above that of the ambient with no accompany- ing ventilation. This has resulted in an atmosphere high in moisture content and well adapted to fungus development. Where air conditioning has resulted in dehumidification of air, storage has proved highly successful.

Heated closets or chests, often re- ferred to as "dry closets" or "dry chests," have proved highly effective in the humid tropics for the storage of vari- ous equipment. In fact, in many tropi- cal areas no home is without its "dry closet" for storing clothing, linens, cameras, and other materials which might "mildew" or become damaged by mois- ture. When properly constructed and ventilated, these heated closets are effec- tive drying units. However, they are usually built with little thought of the principle involved in their proper func- tion. Commonly, every effort is made to make the construction as airtight as pos- sible As a matter of fact, the unit can function in drying only when there is provision for proper ventilation. The principle involved in ventilation is as fol- lows: Moisture-laden air enters at the temperature prevailing outside the cham- ber. When it is heated, it must take on additional moisture which it secures from the materials within the chamber. This heated air, laden with additional mois- ture, then rises to the top and passes out the vent. If no ventilation is provided, both temperature and humidity remain high, and no value is secured by this type of storage. If too much ventilation is provided, the air is not properly heated and there may be little, if any, drying effect upon the contents of the closet. In Figure 8 a storage closet is pictured showing heaters and type of ventilation found satisfactory.

Heating is usually accomplished by a series of electric bulbs or by small strip heaters such as are sometimes used to prevent rusting and mildewing in pianos during humid weather. The amount of heat to be supplied must be determined by trial. A temperature differential be- tween the inside of the closet and the outside of 10° to 15° F. will usually keep the relative humidity at a point where storage is safe. It is important to check the temperature frequently, especially during the first days of use. Tempera- tures over 120° F. should be avoided. Portable chests of this sort have been used with excellent results in the Pacific war theaters for storing aerial cameras and other optical equipment.

When it is necessary to store equip- ment in an area where electric current is not available, a similar dry locker or chest may be used in which the drying is accomplished by a chemical desiccant

FIG. 8. TWO PHOTOGRAPHS OF A "DRY CLOSET"
Left: CLOSED DOOR WITH VENTILATION HOLES. *Right:* HEATING UNIT AND STORAGE FACILITIES INSIDE.

rather than by heat. Silica gel, freshly baked for two hours at 250° F., should be placed in a chest constructed with special care to make it airtight and in which no ventilation is provided. One pound of such silica gel for each two cubic feet of content may keep the humidity in such a chest within a safe range for a month, provided the chest is opened infrequently. Silica gel containing cobalt chloride indicator should be used. As soon as it has turned from blue to pink it should be rebaked at once.

Acceptance Testing of Materials. If materials susceptible to fungus attack in the tropics are to be replaced by those naturally resistant to fungi or made resistant by the incorporation of fungicides, it becomes essential to evaluate many classes of materials with respect to fungus resistance. Such acceptance testing has been practiced in industrial and service laboratories since its need became evident. However, the methods used in the tests have differed so markedly that results have been much at variance between different laboratories. The need for coordination and standardization of these methods became evident.

Evaluation of such materials as hook-up wires, plastics, coating materials, treated cork and leather, photographic films, and many other constituents of elaborate equipment may be made by three possible test procedures: laboratory

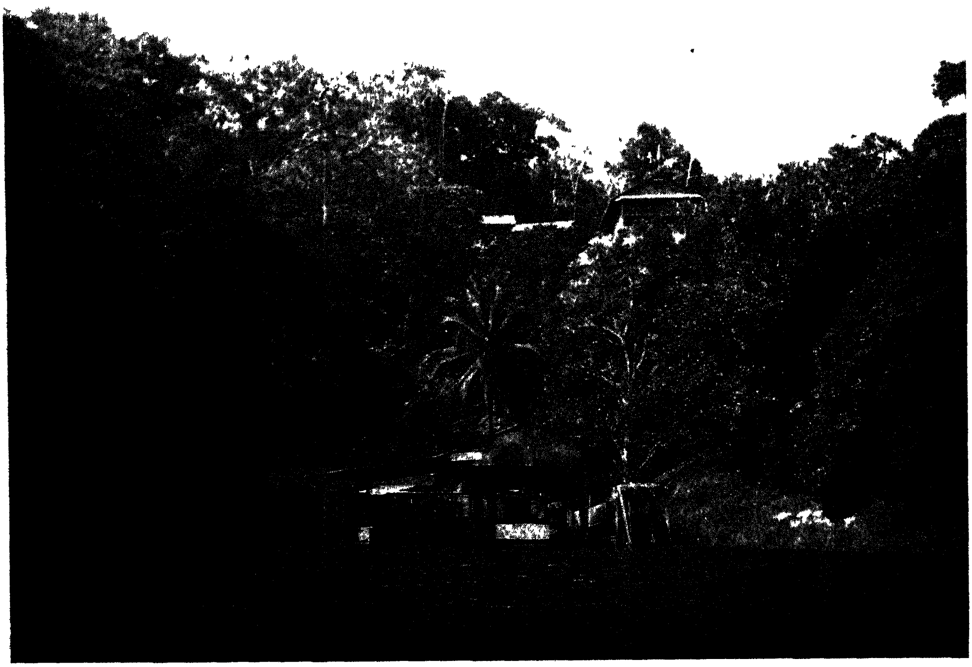


FIG. 9. APPROACH TO BARRO COLORADO ISLAND FROM GATUN LAKE
THE BUILDINGS AT THE TOP OF THE HILL HAVE BEEN USED AS A TEMPORARY TROPICAL STATION FOR THE STUDY OF DETERIORATION. OPEN EXPOSURE AREAS AND PROTECTED CHAMBERS WERE USED IN JUNGLE.

testing by accelerated methods, testing in tropical rooms under simulated tropical conditions, and testing in the tropics.

While ultimate decision with respect to the usefulness of a material must be based upon its behavior in the tropics, it is impossible to await results of relatively long tropical exposure for all classes of materials. It is essential that a certain amount of laboratory testing be done to provide tentative answers with as little delay as possible. It then follows that the methods of testing must simulate tropical conditions and introduce no factors other than those encountered in a tropical environment.

An extensively used acceptance test for hook-up wires and coating materials evaluates the samples on a nutrient medium inoculated with fungus spores. The molds make a vigorous growth on the medium but do not grow into a specified "zone of inhibition" if the material is to receive a favorable rating. This zone does not measure the ability of the test specimen to support growth but the diffusability of some water-miscible fungus inhibitor contained in the specimen. A method devised for the Sub-Committee on Coordination of Test Methods substitutes a mineral salts culture medium containing no organic nutrient. The test specimen itself must therefore contribute the organic nutrient to support fungus growth. Hence a favorable rating is received only if the fungus inoculum is unable to make any marked development on the sample.

Any testing performed *in vitro* must be considered as a screening test and must be regarded as reliable only to the extent that its results can be shown to correspond with those of tropical exposure.

Testing of materials in so-called "tropical rooms" has received much attention during the war. At the University of Pennsylvania such a testing room has been in operation for over two years By automatic cycling the average diurnal temperature and relative humidity range of the humid tropics may be duplicated. A quantity of leaf litter from tropical plants is kept inoculated with several tropical strains of molds and with mites and several small insect vectors of molds. It is believed that such a unit or the larger one recently described by Cooke and Vicklund[1] represents as faithful a simulation of a tropical environment as may be secured in the Temperate Zone. It should be pointed out, however, that a complete tropical environment may be impossible to duplicate in all its climatic, biological, and physical details.

For the University of Pennsylvania tropical room it has been shown that the deterioration of optical instruments, cork, packaged rations, leather, and plastics proceeds at about the same rate as occurs in the Panama Canal Zone during the rainy season.

With the realization that evaluation of materials by testing *in vitro* or in tropical chambers can be meaningful only in the light of correlation with actual tropical exposure, a laboratory for testing and research was established in the Panama Canal Zone early in 1944. Through the courtesy of the Board of Directors of the Canal Zone Biological Area this laboratory was established at Barro Colorado Island in Gatun Lake. In Figure 8 is shown the approach to the island with the laboratories and living quarters made available for the men working on tropical deterioration. Because of the character of vegetation of the surrounding jungle and climatic factors this region has been described[3] as similar to a monsoon forest area. During eight months conditions for testing equipment under humid jungle conditions are ideal. A dry season of about four months results in drying out of materials exposed out-of-doors. However, in closed exposure chambers the relative humidity has remained sufficiently high throughout the dry season to induce molding of leather, cork, plastics, hook-up wires, and optical instruments. Over fourteen thousand items of service materials have been tested at Barro Colorado Island for resistance to fungus attack. A collection of microorganisms associated with deteriorated samples has been made and sent to the tropical fungus collection maintained at Harvard University. In the case of several test materials, replicates have been tested by *in vitro* methods, by tropical room exposure, and by exposure at Barro Colorado Island. It has thus been possible to correlate to some extent these laboratory methods with actual tropical exposure.

To a microbiologist humid tropical areas represent regions replete with possibilities for investigation. Problems of deterioration can be studied far more effectively in the areas where they occur than in far distant laboratories. Military experience in the humid tropics has brought to light many problems other than those of deterioration that require investigation. Problems in medicine, public health, engineering, chemistry, geology, and all branches of biology are familiar to scientists acquainted with these areas. Thought should be given to the establishment of some scientific center in the humid tropics for the study of problems peculiar to those regions.

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WHAT SOUND HATH WROUGHT—II*

By NATHAN LEVINSON
WARNER BROS. PICTURES

WITH the introduction of the sound picture came the creation of the studio Sound Department. The personnel of this department is headed by the Director of Sound Recording, whose position is both administrative and technical in character. He has complete authority with respect to the operations of his department, and it is his responsibility to secure the best recording possible at a reasonable cost of operation and under a wide variety of recording conditions. Although engaged in work highly technical in character, the Sound Director must be appreciative of the fact that he is surrounded by people in many branches of the creative arts, and his success is largely determined by his ability to coordinate the technical efforts of his department with the functions of other studio groups. In many instances the Sound Director exercises some control over the processing of photographic sound records by the film laboratory, and he is vitally concerned with the quality of sound reproduction of his product in the theater.

The varied nature of the problems confronting the Sound Director requires that he have a number of capable assistants to handle the many operations with which his department is concerned. The Chief Engineer is responsible for all the purely technical phases of sound department operation, including the installation, operation, and maintenance of studio recording and reproducing equipment and the development of improvements in technical facilities. The Chief Mixer provides the working contact between the Sound Director and the various staff units working on each picture. He checks the daily product of the Sound Department and assumes responsibility for the techniques and practices of the sound crews assigned to production units. Supervision over those men who actually operate the recording machines is frequently delegated to a Chief Recorder. The operation and maintenance of recording circuits and associated equipment are supervised by one or more Transmission Engineers, who are responsible to the Chief Engineer.

Since the introduction of film recording, the sound crew assigned to a production unit normally consists of four men. This group is headed by the Mixer, who is directly responsible for proper positioning of the microphones on the set, control of the sound volume recorded, and for the acceptance or rejection of each recording made on the basis of the quality and perspective of the sound as judged through his monitoring system. The Mixer often has a technical background, although this is not a specific requirement for his work. He should be capable of critical appreciation of the quality and general character of the sound required to match the action on the motion-picture set.

The Mixer generally has two assistants known as Stage Helpers, whose duties consist of providing proper suspension for the microphones, connection of the various microphones to their associated amplifiers and to the mixing equipment, and the general execution of the Mixer's instructions as to the handling of the microphones during recording.

The remaining member of the sound crew is the Recorder, who is responsible for the operation of the recording ma-

* Continued from page 109 of preceding issue.

THE SOUND MIXER

IN THE MONITOR ROOM THE MUSICAL DIRECTOR LISTENS INTENTLY AS THE SOUND MIXER SWELLS AND MODULATES THE MUSIC OF A SYMPHONY ORCHESTRA BELOW, WHICH IS RECORDING THE SCORE FOR *Juarez.*

chine and its auxiliary equipment, and in some cases for the operation and maintenance of all the recording channel equipment. This man is usually a highly trained technician who possesses at least a working knowledge of the fundamental principles of amplifier operation and testing, optical system adjustments, and film recording and processing techinques.

The daily product of Sound Department operations appears in the form of a number of film sound takes, each of which is matched by a corresponding picture scene, or take. After both picture and sound have been checked and approved by the producer of the picture, the director, and the Sound Department, they are delivered to the studio Editing Department. Here the picture editor proceeds with the assembly of the various scenes in a sequence which is believed most suitable for the presentation of the story involved in the picture. The assembled lengths of picture and sound track prints are accurately synchronized with the aid of synchronizing marks photographed on both the picture and sound film.

Within a period of one to three weeks after the last scenes of a picture have been photographed, the Editing Department will have produced a so-called rough cut print of the picture. The length of the picture at this stage may be 3,000 or 4,000 feet greater than that of the picture in its final form. The producer of the picture, the director, the head of the Editing Department, and the picture editor then project the picture a number of times to determine whether the sequence in which the scenes

have been assembled is the most advantageous that can be devised, whether certain scenes should be deleted from the picture to secure improved tempo, and whether any retakes are necessary to provide a smoothly moving narrative. The picture is then re-edited and is again reviewed to determine what further improvements can be made by shortening or deleting scenes or by rearrangement of their sequence. This process is repeated as often as is deemed necessary to secure the maximum dramatic value from the story. The length of the average fully edited feature picture is of the order of 9,000 feet.

Sometime prior to completion of the editing process, the Editing Department will order the production of the necessary lap dissolves, wipes, fades, montages, and other special photographic effects required for a smooth and effective presentation of the screen story. After these elements have been introduced into their proper places in the pictures, the edited picture print or a copy thereof is turned over to the Music Department for preparation of the musical score.

One of the most important adjuncts of the sound motion picture is its accompanying synchronized musical score. Under present production techniques the musical score for a picture is prepared after editing of the picture has been completed.

This technique could not, unfortunately, be employed prior to the development of methods of re-recording sections of original sound records to a final release record. During the production of early sound pictures, when all sound records took the form of disc recordings, such music as was required for a picture had to be produced on the sets employed for the picture. Keeping in mind the fact that it was necessary to record and photograph all sound and action required for a single reel of film in one continuous operation, one can well imagine the difficulties of securing a perfect continuous performance by actors and actresses as well as the recording orchestra over the period of eight to eleven minutes required for the production of a single record. Special music had to be written for each reel of film, and a great many rehearsals were required before both players and orchestra had sufficiently familiarized themselves with their parts to permit an attempt at recording and photographing the scenes comprising a reel of film entertainment.

The need for the preparation of special music for every picture led to the organization of a Music Department in each of the studios Some of the country's finest composers, arrangers, and conductors rapidly acquired the technique of adapting existing musical scores or preparing original scores for the rapidly growing sound-picture industry, and from their efforts have come the endless succession of hits in the field of popular music.

The scoring of sound pictures was greatly simplified when disc recording gave way to the photographic process. Since a film record could be quickly and conveniently edited in the same manner as picture film, the need for scoring complete reels of picture in one operation no longer existed, and modern scoring techniques came into being. The typical feature picture is scored by a studio orchestra maintained for this purpose, although occasionally the more pretentious pictures employ the services of various nationally and internationally known musical groups. The score for every picture is written to suit the moods and tempo of the various scenes, and the music prepared for one picture is seldom, if ever, later employed in another.

As soon as the scenes of a picture have been assembled in the sequence believed most desirable, the Director of the Music Department assigns a composer and an

RECORDING SOUND
SOUND FROM THE MIXER IS RECORDED BY THE LATEST TYPE OF RECORDING APPARATUS.

orchestrater to the preparation of a musical score particularly suited to that picture. The picture is projected several times to enable the composer and orchestrater to familiarize themselves with the situations, moods, and tempo of the picture subject matter. The producer of the picture, the musical director, the composer, and the orchestrater then discuss and decide which of the picture sequences should be provided with a musical score. The nature of the underlying musical theme may also be discussed at this time.

Each sequence of the picture is then carefully timed on moviola equipment, and detailed cue sheets containing information with respect to all the important action and dialogue of the picture are prepared to aid the composer in most effectively fitting each musical sequence to the corresponding picture.

The composer's task is essentially one of creation, the effectiveness of his work being measured by the degree to which the musical score enhances the dramatic effect of the picture. An effective musical score may be brilliant, dynamic, or subdued, but it must never attract attention at the expense of the picture.

The composer prepares his material in the form of a piano sketch and generally indicates which sections of the orchestra are to be employed for the various musical sequences. The orchestrater, or arranger, employing the composer's sketch as a guide, assigns a voice to each individual instrument so as to obtain proper tonal balance in the final orchestration. When the nature of the picture so demands, the arranger may completely alter the tempo and character of a section of the theme to dramatically emphasize certain picture sequences.

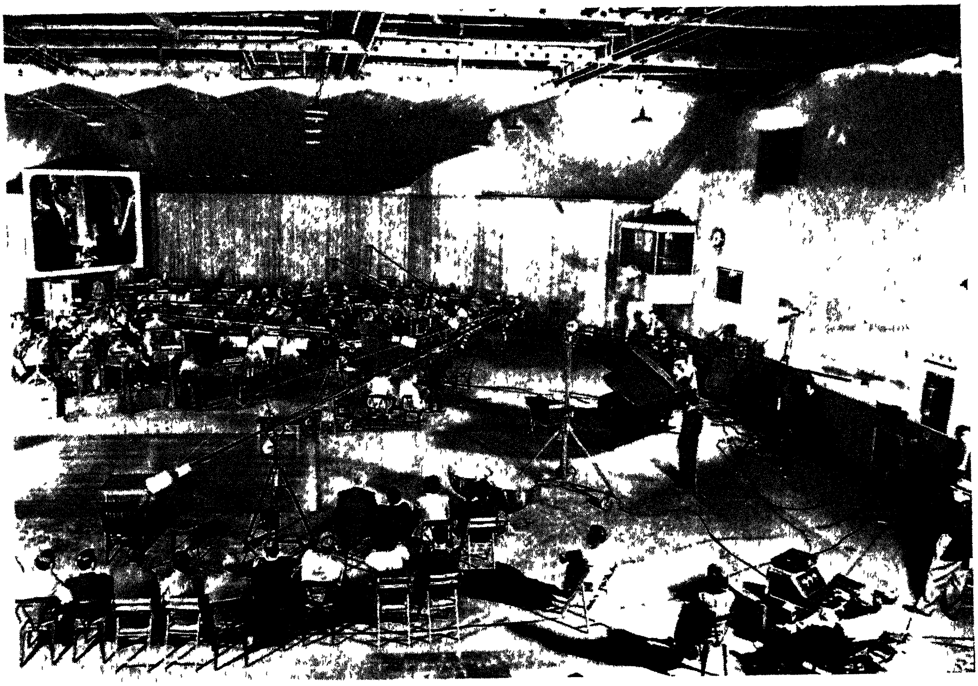
With the completion of the orchestration, the arranger's material is turned over to a staff of copyists, who extract the individual instrumental scores from the orchestration. A music proofreader, who is usually a capable composer, checks the final score for errors, after which the music is printed in suitable form for the orchestra.

The procedure outlined above is generally followed in the production of all pictures except those which feature musical numbers or elaborate dance sequences. In the case of such pictures, a composer is assigned to the preparation of the musical score as soon as the picture script has been completed, in order that the score required for the special sequences may be available before the corresponding scenes are photographed. A recording of the music for these sequences is then made in the normal manner on both film and disc records. The disc records are reproduced on the stage at the time that these sequences are photographed, so that the action may be perfectly synchronized with the musical score. No sound is recorded while the scene is photographed, since the original film record of the musical score will be in exact synchronism with the action and may be employed in the final re-recording process.

Most picture scoring is carried out on stages which have been specifically designed for this purpose. The general stage construction is similar to that of other sound stages, differing principally in that the acoustic treatment of walls, floor, and ceiling is given greater consideration. A motion-picture screen fitted to the stage wall in such a position as to be clearly visible to the orchestra conductor and the sound mixer, together with appropriate motion-picture projection equipment, enables those immediately concerned to accurately fit the tempo and length of each musical se-

EARLY MUSICAL RECORDING

PREPARATION IS MADE TO SHOOT THE MUSICAL SCENE. NOTE THE SOUNDPROOF BOOTHS ON THE STAGE.



RECORDING MUSIC
THE MUSIC IS PLAYED TO MATCH THE FILM WHICH IS PROJECTED ON A SMALL SCREEN IN THE CORNER.

quence to the corresponding picture action. The sound-recording equipment employed for scoring is usually identical with that used for production recordings, with the possible exception of more elaborate channel supervisory and intercommunication equipment. Permanent monitoring facilities for the recording channel are set up in monitoring rooms which form a part of the scoring stage, and double plate glass windows afford the sound mixer a view of the musicians, the conductor, and the screen, at the same time providing sufficient sound insulation between the stage and the monitoring room so that the mixer is not confused by sounds from the stage combining with those from his monitor speaker system.

Each reel of the picture is scored in sections, the numerous takes being later spliced to form a continuous sound track. One advantage of this mode of operation lies in the fact that the musicians are able to give a practically flawless performance after a number of brief rehearsals, whereas if an entire reel were scored during a single take the physical and mental strain would be far greater on all concerned. Music scoring as generally practiced is termed a postrecording process, since it is not begun until photography and editing of the picture are completed.

When scoring is completed, the various film records corresponding to the musical sequences for the picture are assembled in precise synchronism with the edited picture print prepared by the studio Editing Department. This operation is conducted under the supervision of a qualified member of the Music Department. During this period the numerous separate film records of necessary sound effects are also synchronized with the action of the picture. The final sound record is secured by re-recording simultaneously the dialogue sound track,

the music sound track, and the sound effects tracks to a release sound negative. Final release prints for the theater are obtained by printing each reel of the edited picture negative and the corresponding re-recorded sound negative on a single length of film. In this manner exact synchronism between picture and sound is assured in the theater.

The process of preparing the final sound record to accompany the picture in the theater is a highly specialized one and is generally conducted by a separate division of the Sound Department. The equipment required for this process is basically similar to that employed for stage recording, with the exception that the microphones are replaced by high-quality film reproducing machines in which the various photographic sound records to be combined in the final release record are reproduced as electrical signals. These signals are combined in proper proportion through suitable control circuits, and the resultant signal is again recorded on film.

The re-recording control console is generally located in a re-recording room designed to simulate, in proportions and acoustic characteristics, a small theater. Motion picture projectors located in a booth adjacent to the re-recording room provide a picture image of theater size on a screen located an appropriate distance in front of the re-recording control console, thus enabling the sound mixer to judge the quality and proper combination of the several sound records being re-recorded for the final sound track in terms of the pictorial effect with which that track is associated.

During the final process of re-recording, the music director, the composer, and the arranger have an opportunity to determine how satisfactorily the musical score matches the moods and tempo of the picture. On many occasions it is found desirable to delete or to lengthen certain musical sequences, and these operations are again conducted under the general supervision of a representative of the Music Department.

All feature pictures are previewed to secure public reaction before the picture is considered completed. Following the preview, and depending largely upon the nature of the preview audience reaction, the picture may be re-edited to strengthen certain sequences or to improve tempo or continuity. In such cases corresponding re-editing of the dialogue, music, and sound effects records is necessary, and a second re-recording operation is required to secure a release sound track which matches the re-edited picture.

The tangible result of Hollywood's annual production activities takes the form of hundreds of millions of feet of processed motion picture film. Elaborate facilities are provided for developing, fixing, washing, drying, cleaning, waxing, identifying, handling, storing, and shipping this film. All film development is carried out with the aid of continuous processing machines, the solutions employed being continuously filtered and automatically maintained at the optimum temperatures. The finest air conditioning equipment is employed to insure an adequate supply of clean air, of proper temperature and humidity, to all sections of the laboratory buildings.

Much of the present film laboratory equipment and several of the most important film processing techniques have been developed to permit proper processing of photographic sound records.

During the early days of the silent motion picture, film development was accomplished by winding the exposed film on suitable racks and manually submerging rack and film in tanks of developer solution. Fixing and washing of the film was carried out in a similar manner. The quality of development was determined entirely by visual inspection, and varied from hour to hour

THE LATEST TYPE OF EQUIPMENT

A SCENE FROM *Night and Day* ILLUSTRATES A NEW ROVING MICROPHONE AND TECHNICOLOR CAMERA.

and day to day. Nonuniformity in the development of adjacent lengths of film was practically unavoidable and gave rise to so-called "rack flashes," which were manifested by periodic variations in brightness of the picture on the theater screen.

The introduction of machine developing methods did much to overcome the nonuniformity of manual development, but control of the developing process was still based principally upon visual inspection of the final product. Machine processing of release prints preceded that of negative materials by a number of years, a situation that was brought about partly through fear of loss or damage to the more valuable negative film, and partly because the smaller total footage of negative stock involved did not actually necessitate the use of the more rapid processing which machine development provided. Fortunately, continued improvements in the design of processing machines removed all objections to their use for the development of both negative and positive materials, and the advantages provided by machine methods were so attractive that all film was being processed in this manner sometime prior to the introduction of the sound picture.

The first large-scale commercially employed photographic sound records were of the variable density type and required extremely uniform and accurately controlled development to prescribed negative and print gammas to insure satisfactory quality. Such processing could only be secured with the aid of sensitometric control of the degree of film development. Unfortunately, the merits of sensitometry were not widely recognized in the Hollywood laboratories when sound engineers first became concerned with the processing of film records, and

equipment required for each of the studio theaters or review rooms represented an additional outlay of approximately $10,000. Thus, the new plant investment for a studio converting from silent to sound production and requiring six sound stages, four recording channels, two mobile recording channels, and two review rooms would average somewhat more than $1,000,000. Approximately double this amount of equipment was installed by each of the major studios within a few years after full-scale production of sound pictures got under way.

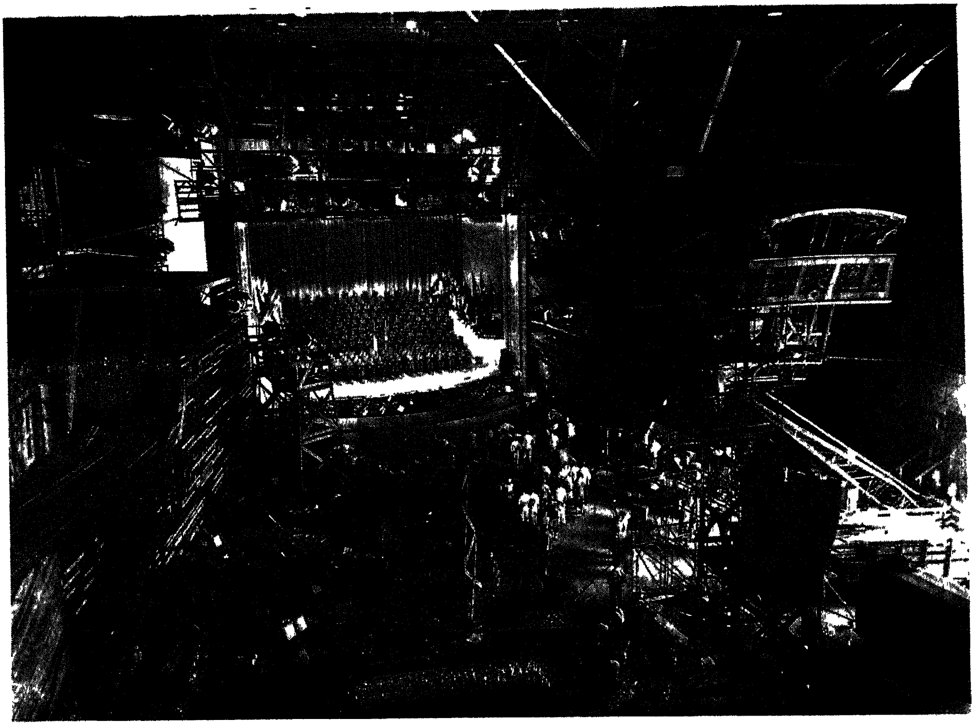
The increase in the number of studio employees due to the advent of sound was much larger than might at first be imagined. A Sound Department engaged in the operation of four fixed and two portable recording channels and in maintenance of the recording and theater equipment would require the services of approximately fifty to sixty men. Such a group would not increase the size of a studio pay roll by an appreciable percentage. However, to this number must be added the increases required in other studio departments. For example, proper control of the set lighting units during the long takes of the early sound pictures required the services of one stage electrician for each of the large lamps employed. The personnel of the studio electrical department was thereby practically doubled. The more stringent requirements on set construction made it necessary to more than double the personnel of the studio Art Department, and this in turn required corresponding increases in the number of carpenters, machinists, painters, and other craftsmen concerned with the production and erecting of set structures.

Silent pictures were generally shot with a single camera, the various camera angles necessary to secure satisfactory tempo of the finished production being secured through repeated photography of a given scene from appropriate camera positions. Until the process of dubbing sound records had received considerable development, it was necessary to secure all of the camera angles required for a scene, as well as the sound record, during a single take. The number of cameras and cameramen required for this operation was three or four times greater than that which had been required for a silent production, and the studio Camera Departments expanded correspondingly.

The need for the creation of Music Departments and Story Departments has already been noted. The labor of editing a picture was practically doubled with the introduction of sound, and the Editing Departments experienced a corresponding growth. The increased volume of film processed by the film laboratory and the requirements of accurate sensitometric control of film processing very appreciably increased the number of laboratory personnel required.

The art of process photography had been under development for some years prior to the introduction of sound but had been employed principally to secure photographic effects which could not readily be obtained by direct photography. With the introduction of sound the great increase in personnel required for production on locations stimulated the further development and application of process photography, since this technique permitted the production of scenes in the studio which could otherwise only have been obtained by transporting a full production company to distant locations. The rapid growth in the application of process photography effectively resulted in the organization of another studio department which had not previously existed.

The growth of the several departments named above was matched by a corresponding growth in the personnel of administrative, sales, publicity, and transportation departments. As the period required for the production of a sound



THE COMPLETE SOUND STAGE
SHOWING THE MODERN EQUIPMENT AND CREW NECESSARY TO SHOOT A SCENE FROM *This Is the Army*.

picture was greatly increased over that required for a corresponding silent picture, the production of a given number of feature pictures per year necessitated a large increase in the number of directors, players, and extras employed by the studio.

When all the personnel additions mentioned above are taken into account, it is found that the studio personnel increase directly attributable to the introduction of sound was of the order of 100 to 150 percent and that the cost of production was increased by 300 to 400 percent Keeping these facts in mind and noting that the conversion from silent to sound production was scarcely completed prior to the crash of 1929, it is not surprising that many of the major motion-picture production organizations experienced the greatest difficulty in surviving the depression period.

The owners and operators of large theater chains were also confronted with a number of formidable problems during the period of conversion from silent to sound pictures. The first arose in securing a sufficient amount of theater sound equipment to permit rapid conversion from silent to sound projection; a second difficulty was presented by the problem of financing the purchase of this equipment. Sound equipment for a small- or medium-sized theater called for an expenditure of $10,000 to $20,000, while the investment required for the larger houses was in the neighborhood of $25,-000. Such additional problems as were brought about through unexpired contracts for silent pictures, for large theater orchestras, for organists, and for vaudeville acts were responsible for the consumption of goodly quantities of aspirin, for few people in the theatrical

field were inclined to believe that the sound picture represented more than a passing fad.

It now seems safe to predict that the sound picture will be with us for some time to come. Continued improvements in recording and reproducing equipments and in production techniques have removed practically every restriction that sound ever placed on motion picture production and have tremendously widened the scope of screen entertainment. It is no easier to predict the future developments of the sound motion picture now than it was to foresee its tremendous future in the year 1926. The value of the sound film as a medium of education has long been realized, but little has yet been accomplished in this field. The widespread use of sound-motion-picture training films during the recent wartime period is well known. Many large industrial organizations produce a number of highly specialized training films for their personnel each year, and the use of sound pictures as an advertising medium is already well established. Future generations will have available complete records of many events of historical importance in sound-motion-picture form.

Demonstrations of stereophonic sound pictures have been given a number of times in the past, and the development of equipment and techniques for the production of such pictures is proceeding at the present time, hampered somewhat from the knowledge that the investment required for new studio and theater equipment necessary for the production and showing of such films will be enormous when compared to the corresponding investment required for the introduction of the present sound picture.

The part to be played by the sound picture in the development of television is as yet unknown. Keeping in mind, however, that the motion picture provides the only means by which completely pre-edited entertainment can be provided, one would be surprised if a major portion of the best future commercial television programs was not derived from sound motion pictures produced especially for this medium.

The utilization of large quantities of narrow gauge film, particularly in the 16 mm. size, for industrial training, advertising, home entertainment, record pictures, and military applications, had led to numerous improvements in equipment and technique for the production of high quality substandard gauge sound films. The principal advantage offered by such film sizes is that of economy, for in all technical respects the quality of both picture and sound is, and must remain, inferior to that which may be derived through the use of 35 mm. film. However, the difference in costs between 16 mm. and 35 mm. professional cameras, recording equipment, processing and editing equipment, and projectors is very appreciable, as are the differences in raw film costs. The smaller bulk of a picture on substandard film sizes also offers considerable advantage when storage space and transportation costs are taken into account. It is inevitable, therefore, that such film will find increasing application. It is ideally suited to the presentation of educational subject matter and may even prove an able competitor to 35 mm. film as an entertainment medium in the smaller communities in this country and abroad.

To state that the sound motion picture has tremendous potentialities in numerous fields which have not yet been exploited is merely to state the obvious. The introduction of sound recording has transformed an entire industry; the sound motion picture can transform entire phases of our social and economic life.

SCIENCE ON THE MARCH

PHASE MICROSCOPY, ITS DEVELOPMENT AND UTILITY

THE development of the microscope into the versatile instrument it is today is high-lighted by outstanding accomplishments interspersed with periods of refinement of details and continuously extended fields of application as a result of improvements in the instrument. Many of these improvements utilize some special optical characteristics of the specimen in order to render it visible. Thus the dark-field microscope forms images by means of the light diffused by small particles. The polarizing microscope utilizes the birefringence of materials. The surface reflectance of specimens enables them to be seen by means of vertical illumination. If particles can be made to fluoresce under the action of ultraviolet radiation, the use of the fluorescence microscope is often advantageous. Direct images are also obtained by the use of ultraviolet radiation in the ultraviolet microscope and by electrons in the electron microscope, depending on the absorption characteristics of microscopic specimens for these rays.

The newly developed phase microscope promises to prove of comparable importance. In nature and industry there are many microscopic materials which are transparent or nearly so, whose details differ from their background in either refractive index or actual thickness, resulting in a difference in light path. The purpose of the phase microscope is to render such details visible with sufficient resolving power for their interpretation.

As is generally the case with scientific developments, the quest for this method has extended over considerable time. Among those whose early investigations have contributed to the development of phase microscopy are: Ernest Abbe (prior to 1892), K. Bratuscheck (1892), A E. Conrady (1905), and J. Rheinberg (1905). It remained, however, for Professor F. Zernike, of Groningen (1935), to show that if an object is illuminated by an extended light source and this light source is focused on a diffraction plate, which must therefore be placed at the geometrical image of the light source, changes in visible contrast in the image of the object can be obtained. Using the method of Zernike, in 1941 Köhler and Loos, of the firm of Carl Zeiss, showed several applications of the method to problems in practical microscopy. Burch and Stock, of London (1942), described their results using a linear, rather than a circular, phase-accelerating element in conjunction with the microscope objective. The Spencer Phase Microscope, exhibited first in 1944 at the Cleveland meeting of the American Association for the Advancement of Science, was the result of experimental and theoretical investigations by Dr. Harold Osterberg and Dr. Helen Jupnik, physicists, Dr. Oscar W. Richards, biologist, and the writer. Subsequently, from our laboratory results have been reported by Bennett (1944), Richards (1944), Osterberg (1944), Jupnik (1944), and a more comprehensive report by Bennett, Jupnik, Osterberg, and Richards (1946). The application of this microscope to biological purposes was reported by Richards (1946).

The Spencer Phase Microscope is shown diagrammatically in Figure 1. An opaque diaphragm *D*, with a clear annular opening placed below the substage condenser *C*, at or near the front focal plane, controls the illumination. This annular stop is imaged by the substage condenser system and the microscope objective at or near the second

focal plane of the latter at *P*, where the diffraction plate is placed. The purpose of this plate is to introduce either a phase difference or an amplitude, and hence intensity, difference or both over portions of the light waves emerging from the specimen on the stage *S*. The remainder of the microscope is unchanged. Thus the annular ring diaphragm *D* and the diffraction plate *P* are the only additional equipment necessary for obtaining phase microscopy with the ordinary microscope.

The diffraction plates consist of the *B*−, *B*+, *A*−, and *A*+ types shown in Figure 1. Dielectric materials, illustrated by the half-shaded areas, are deposited by evaporation for the purpose of introducing phase differences; thin coats of metal, illustrated by the full-shaded areas, are deposited for controlling the light transmission, and hence the amplitude ratios. The annular ring on this plate is of the same size as the image of the condenser ring diaphragm. All the direct light from the specimen must, therefore, pass through the ring of the diffraction plate. Other light which has been diffracted by the structure of the specimen passes through the remainder of the diffraction plate. The plate introduces phase and intensity differences between the direct and diffracted light from the specimen, which, when combined in the image, may produce greatly increased visibility. The equipment is simple in construction and easy to use.

This form of microscopy has been found useful in the examination of objects in which the details have little or no optical contrast but differ from their surroundings only in refractive index or actual thickness, and thereby in light path. The details of such specimens can be made to appear either brighter or darker than their background Many examples are to be found in industrial and scientific fields, such as crystals in their mother liquor, living cells, tissues, bacteria, parasites, molds, synthetic and natural fibers, emulsions, transparent replicas of surfaces, and minute surface effects on glass or plastics. Staining of specimens is unnecessary, and examination of living organisms can be made.

Figure 2 shows photomicrographs of β-naphthol crystals in brine. *A* shows that little can be seen with the ordinary bright-field microscope with the condenser stopped down to give maximum contrast in the image. *B* was taken with the Spencer Phase Microscope with a diffraction plate of the *A*+ type whose annular ring was coated with metal so as to transmit 7 percent of the direct light and with dielectric material of such thickness that the direct light is retarded by one-quarter of a wave length more

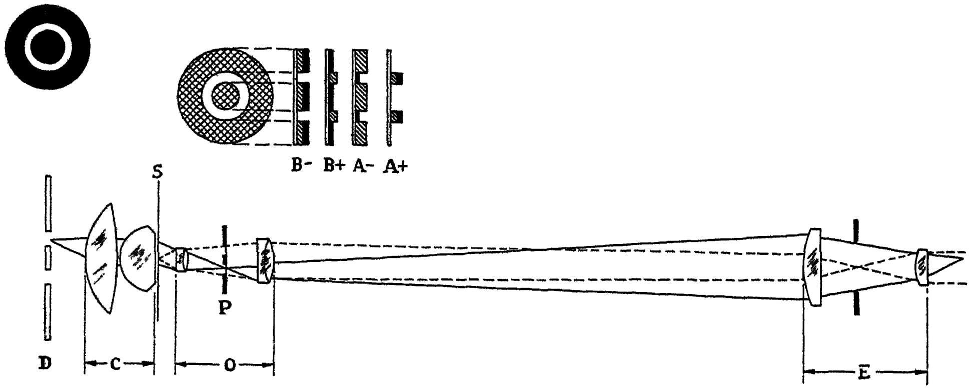


FIG. 1. OPTICAL SYSTEM OF THE PHASE MICROSCOPE

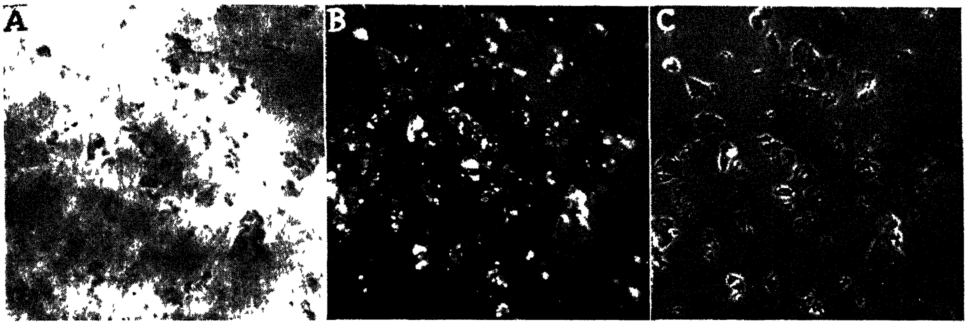


FIG. 2. PHOTOMICROGRAPHS OF β-NAPHTHOL CRYSTALS IN BRINE
A: WITH THE ORDINARY BRIGHT-FIELD MICROSCOPE; *B* AND *C*: WITH THE SPENCER PHASE MICROSCOPE. MAGNIFICATION, 213×; OBJECTIVE, 4 MM; EYEPIECE, 10×.

than is the diffracted light. *C* shows the same specimen with reversed contrast produced by use of an *A*– plate wherein the ring transmits 20 percent of the incident light but contains no dielectric material. The dielectric material is applied to the remaining portions and is of such thickness that a retardation of one-quarter of a wave length of light is obtained

One of the important results of our investigation is that no one diffraction plate is suitable for all types of specimens. It has been found necessary to select the magnitude of the light retardation and absorption, also the type of diffraction plate—whether *A*+, *A*–, *B*+, or *B*– —(Fig 1) in order to obtain optimum visibility for particular types of specimens.[1]

At present the range of plates necessary for a large variety of specimens has been determined as a result of experience in the examination of many kinds of material, and further investigation is in progress.

[1] In contrast to this observation, a few "phase-contrast" units made by the firm of Carl Zeiss and recently brought to this country after we had exhibited the Spencer Phase Microscope have only one diffraction plate of the *A*– type for each objective lens.

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THE VOYAGE OF THE *CHALLENGER*

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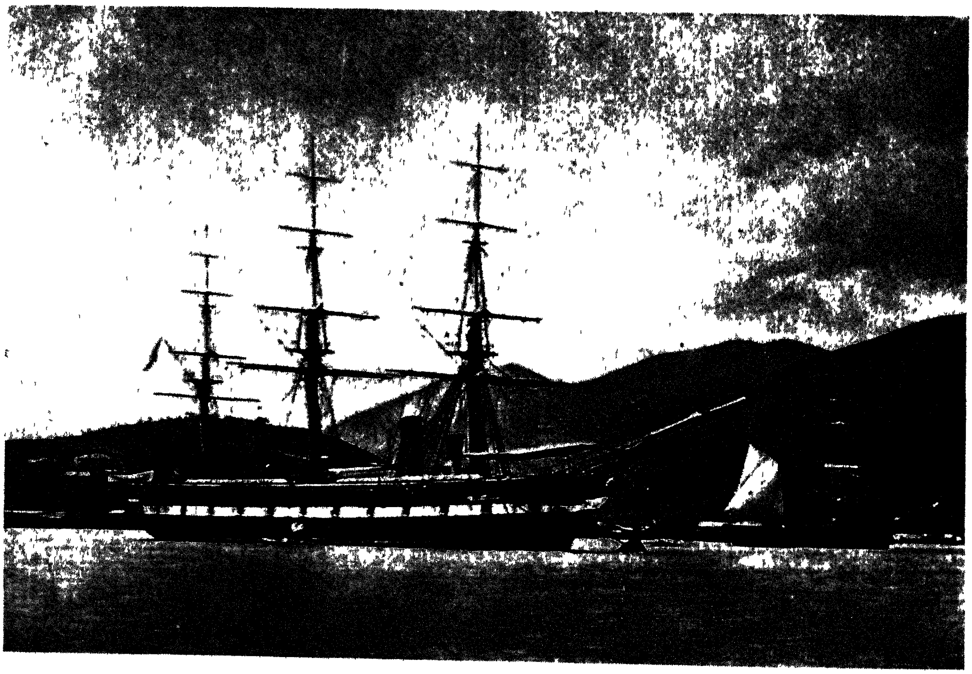
SEVENTY years ago, on May 24, 1876, a seaworn British man-of-war, disarmed and laden with a most unwarlike cargo of mud samples and pickled specimens of creatures from the ocean depths, dropped anchor at Spithead after a three-and-a-half year absence from England. Thus, without fanfare or cheering crowds, H.M S *Challenger* came home, and with the completion of her peaceful voyage of 68,890 nautical miles the new science of oceanography was well begun. It was a long and adventurous voyage, which more than fulfilled the expectations of those who had planned it, although it upset some of their favorite theories about the active formation of chalk on the ocean bottom and the occurrence of the primordial stuff of life in the depths. The voyage also established the reputations of several young gentlemen who had shipped on as naturalists at a salary of £200 per annum, and it nearly bored many of the naval staff to tears long before it was over.

It has been said that the primary motivation of the *Challenger* Expedition was the hope of proving the "continuity of the chalk" and the prevalence of bathybius, but the expedition was planned on such a broad and inclusive scale that the refutation of these popular theories early in the voyage had little effect on its course. The credit for conceiving and instigating the *Challenger* Expedition belongs to Professor Wm. B. Carpenter,



H.M.S. *CHALLENGER*, ST. THOMAS, W. I., MARCH 1873

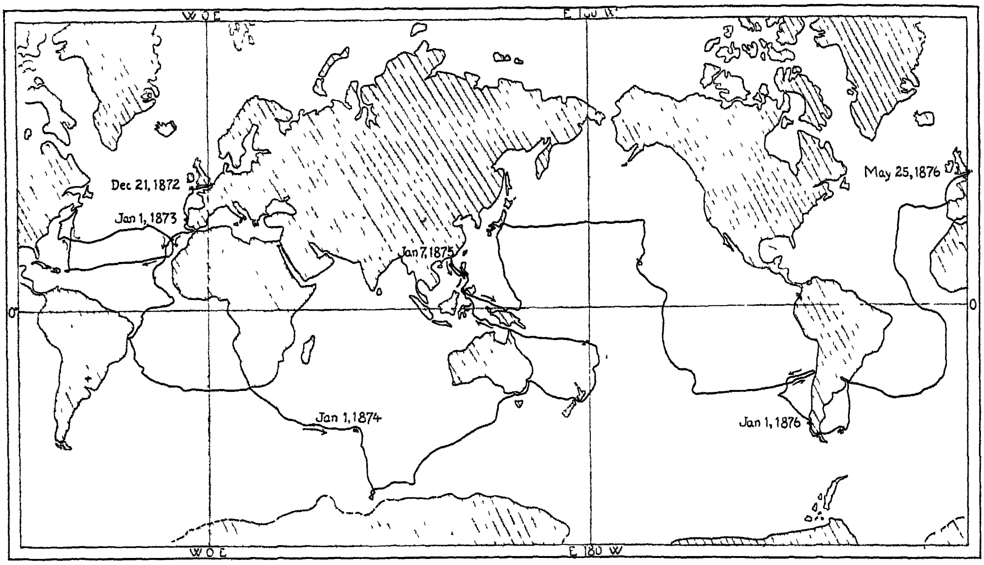
of the University of London, and Professor Charles Wyville Thomson, of Edinburgh. Convinced of the need and value of deep-sea exploration by their preliminary dredging work around the British Isles on H.M.S. *Lightning* in 1868 and H.M.S. *Porcupine* in 1869 and 1870, they decided that the time had come to undertake a more extensive expedition. Evidently many others were of the same opinion, even in naval circles, for Carpenter's preliminary correspondence with the Admiralty on the proposed deep-sea exploring expedition early in 1871 was favorably received.

The Admiralty waited only upon a formal request from the Royal Society, and by the closing months of 1871 a committee of the Society had been set up, and the plans for the "voyage of circumnavigation" were well under way. This committee included, in addition to Carpenter and Thomson, Professor T. H. Huxley, who played an important part in drawing up the research program for the voyage; Mr. Gwynn Jeffreys, an enthusiastic conchologist who was to become the father-in-law of Moseley, one of the young naturalists who made the voyage; Mr. Alfred Russell Wallace; and several other eminent men of British science. Indeed, one misses only the name of Darwin from this committee. By the end of June 1872 the Admiralty had commissioned the *Challenger,* a steam corvette of 2,306 tons, for the voyage, and lost little time after that in refitting her according to the suggestions of the committee of the Royal Society.

The *Challenger,* up to the time of her commissioning as a research vessel, did not have a particularly distinguished record. She was built at Woolwich and launched on February 13, 1858 In 1860 the *Challenger* was sent to Mexico and occupied Vera Cruz in an effort to collect indemnities due British citizens but withdrew without gaining any settlement. Later the ship was sent to Australia and in August 1868 shelled Rewa in the Fiji Islands in retaliation for the murder of a missionary and some of his dependents. Some boats were also sent ashore. As a result of this action, "some natives were killed," and when the *Challenger* returned to the Fijis on the peaceful business of science many of the natives took to the woods. The ship's career after the completion of the cruise was even less distinguished: she was cut down as a barge and remained in this humble service until 1921.

While the *Challenger* was being refitted, the scientific staff for the expedition was appointed, with Wyville Thomson as director. Although he was reluctant to accept this post, which he believed more suitable for a younger man, he agreed to direct the cruise. As it turned out, the long voyage impaired his health, and he did not live to see the reports of the expedition completed or to write a book on the Pacific which he had planned to complement his preliminary volumes on the Atlantic John James Wild, a Swiss artist, was appointed artist and secretary to the director. The remainder of the staff, as originally appointed, consisted of J. Y. Buchanan as chemist and physicist and H. N. Moseley, William Stirling, and John Murray as naturalists. Before the cruise began, Stirling resigned, and Rudolf von Willemoes-Suhm, *Privatdocent* in Zoology, of the University of Munich, was appointed. The most important position of captain of the ship was given to Captain G. S. Nares, an experienced survey officer.

At last the lengthy preparations were completed, the supplies aboard, and the expedition was ready to start upon its four-year course. There had been much publicity in the press, including that inimitable journal *Punch,* which dedicated its December 28 number to the *Challenger,* admonishing the voyagers to read "the whale, by Herman Melville." There had been some questions



TRACK OF H.M.S. *CHALLENGER*, 1872–1876

raised in Parliament, but on being assured that the cost of the expedition would be "no more" than that of keeping the vessel in commission, Parliament approved the funds. "Thus, with every possible advantage, and in the highest hope of being able to fulfill her difficult mission, the *Challenger* cast off from the jetty at Portsmouth at 11:30 A.M. on Saturday, the 21st of December, 1872." The last man aboard was a young navigating sublieutenant, Herbert Swire, who was to be the last survivor of the expedition and the author of its most readable journal.

No better idea of the men who were to be messmates and fellow-adventurers in science for nearly four years can be had than from Lieutenant Swire's journal, as he met them for the first time on board the *Challenger*:

Our civilian scientific staff, on the whole, have turned out pretty good sailors, especially one of them, who has just returned from a "pleasure trip" in a North Sea whaler! . . .

First, then, as head of the civilian staff, we have Professor Thomson, or, rather, Wyville Thomson. He gave up an appointment worth some £2,000 a year to join this ship, where he gets only half that sum, but will doubtless have the satisfaction of placing his name on the roll of fame with those of eminent scientific men who have gone before him. The professor is a stoutish man and has not yet got over his seasickness, so I know little or nothing of him personally. Then there is Murray, naturalist, I think, who is the sailor-like individual before mentioned; Buchanan, whose strong point in science I have not yet discovered . . . ; von Suhm, a botanist and a Dane or German, and decent sort of fellow to boot, and the youngest of the "philosophers," as we call them; Wild, artist and Swiss, who is very dyspeptic and seldom to be observed by the eye *vulgarus;* Moseley, naturalist, and chockfull of science, even unto bursting.

Now of our own people, the first is Captain Nares, who is generally considered to be a devilish good fellow and one of the best captains in H.M.'s Service; he has served in all parts of the world, including the Arctic regions, where he went with the Franklin search expedition. In personal appearance he reminds me intensely of the faces of Elizabeth's reign, Shakespeare, Raleigh, or some such countenance, or perhaps it is Charles I that his face calls up; at any rate there he is, pointed beard, high bald forehead, and head with a full round top: a clever man by the shape of his head, most people would say. Next comes Commander Maclear, who is second in command, and also has charge

of the magnetic department of the expedition, and seems to be a good fellow; in fact, to save time I will at once state as a fact beyond dispute, that we are all good fellows, every one of us.

Among the other members of the naval staff was the son of the Duke of Argyll, Lord George Campbell, who was to write a popular journal of the cruise that went through several editions. He brought along his Newfoundland dog, which was not the least of the *Challenger's* complement of livestock. In fact, the *Challenger* was equipped with a miniature barnyard on the main deck, including "at least twenty ducks, fifty hens and cocks, several geese, and about fifteen sheep." There was also a small garden. Moseley, in his journal, devoted a page or two to an account of the fauna acquired by the ship on her voyage: the unwelcome rats and cockroaches; the spiders, invited aboard by the surveyors, who used their webs in their instruments; and the two parrots purchased by himself and von Suhm. One of the parrots met an untimely end in a pan of hot caustic potash, but the other, named Robert, survived the trip and learned to say as the dredge came up: "What! Two thousand fathoms and no bottom! Ah, Dr. Carpenter, F.R.S."

From the vantage point of seventy years it would seem that all the *Challenger* lacked was a musical score by Sir Arthur Sullivan. Certainly W. S. Gilbert could not have picked a more typically English crew, with the added touch of a foreign naturalist. It is possible that some of the members of the scientific staff realized this, for they cheerfully accepted the familiar label of "philosophers." But it was to be a long, hard cruise, and the young German naturalist was never to see his native land again. Of the 243 men who left with the *Challenger,* 144 returned. Of the original crew, 61 deserted the ship, which indicates that life aboard one of Her Majesty's ships in those days did not appeal to many of the common sailors.

The Channel in December was rough beginning for the voyage, and it was not until December 30 that the first sounding was taken. Then, in Latitude 41° 57′ N., Longitude 9° 42′ W., at a depth of 1,125 fathoms, the dredge was lowered for the first time. The first try was unsuccessful because of the high sea, but on the second attempt a load of mud and a few creatures, including a handsome starfish, were brought up. Champagne was chilled in a tubful of icy ooze brought up by the dredge, and the success of the expedition was drunk. It was not until February 15, 1873, however, that the first official station was taken, at 27° 24′ N., 16° 58′ W., in 1,890 fathoms, about 40 miles south of Teneriffe. This, according to J. Y. Buchanan, was the birthday of oceanography.

ALTHOUGH the original itinerary of the *Challenger* included a more extensive exploration of the South Atlantic than was actually undertaken and a line across the North Pacific to Vancouver which was evidently cancelled because of the transfer of Captain Nares at Hongkong to an arctic expedition, the *Challenger's* voyage still stands as the longest continuous exploration by a scientific vessel. Ships like the *Albatross* and the *Carnegie* logged more miles, but their careers included several separate voyages. Many of the gaps left by the *Challenger* on her pioneer voyage have since been filled by other vessels, but it can still be said that the ocean is but partly explored. There are vast areas in the South Pacific and Indian Ocean which have yet to be sounded—even in these days of rapid sounding methods—let alone sampled for their fauna and tested for their physical and chemical characteristics. The *Challenger* had planned to make a complete station at regular intervals around the globe, but circum-

stances did not always permit this; the total number of official stations was 362.

When the *Challenger* began to dredge, even the deckhands were curious, but as the years wore on fewer and fewer members of the staff remained on hand when the dredge was brought aboard, until at the end only the indefatigable Wyville Thomson remained for a first glance at the booty. It became a tedious chore for the naval staff, and a water haul was often a source of argument as to whether the dredge had actually reached the bottom. When it is remembered what a difficult and dangerous operation deep-sea dredging was seventy years ago, it is remarkable that only one man was killed by a failure of the tackle. Indeed, the loss of equipment during the long voyage was a record any modern vessel might be proud of: although Buchanan's summary of the loss of thermometers is confusing, since his total of 13 thermometers lost does not tally with his itemized list of 19 carried away and the added loss of "two temperature lines . . . with eight thermometers" and still another loss mentioned later. At any rate, it appears that the *Challenger* lost at most 28 thermometers during soundings. According to the official summary, 48 thermometers were expended altogether. The dredging operation was even more successful, for the tackle broke but eleven times during the voyage, leaving a dredge or trawl on the bottom. This record is especially remarkable when it is remembered that hempen sounding and dredging lines were used throughout the voyage and that dredging was a tedious business.

An idea of how tedious it was for those not particularly interested in science can be had from Lord Campbell's *Log Letters:*

Dredging, I may say without fear of contradiction, was our—the naval officers'—*bête noir.* The romance of deep-water trawling or dredging in the *Challenger,* when repeated several hundred times, was regarded from two points of view; the one was the naval officer's, who had to stand for ten or twelve hours at a stretch carrying on the work, and who, always excepting that he did not like his day's work to have been done in vain, did not know much about, or *scientifically* appreciate, the minute differences between one starfish, one shrimp, one sea-cucumber, one sea-urchin, and another. The other point of view was the naturalist's, to whom the whole cruise was a yachting expedition, who had not to carry on the practical working of the dredge, to whom some new worm, coral, or echinoderm is a joy forever, who retires to a comfortable cabin to describe with enthusiasm this new animal, which we, without much enthusiasm, and with much weariness of spirit, to the rumbling tune of the donkey-engine only, had dragged up for him from the bottom of the sea.

Probably some of the young lord's shipmates, when they read these words, thought he was putting on just a little, for Lord Campbell apparently never missed a shore leave and was evidently the ship's most indefatigable excursionist. Lieutenant Swire, who wrote a better journal, was less fortunate. As a member of the surveying staff, he had to spend much of his time ashore on unexplored islands at his instruments while Lord Campbell and the naturalists ranged gaily over the terrain. He also became heartily sick of the dredging and wished for an end to it before the first year of the voyage was out. Another tedious job aboard the *Challenger* was that of the chemist, although that individual left no journal with passages of lamentation about his unhappy lot.

The chemist of the *Challenger* will always be remembered for his bursting of the "bubble of Bathybius." This fabulous substance had been discovered in bottom samples secured on telegraph cable surveys and appeared to be some sort of life. Huxley considered it some sort of amoeba and named it after his colleague Haeckel, and Haeckel considered it the mother of protoplasm. It proved very elusive to the naturalists of the *Challenger,* although they sought it diligently. Buchanan, however, was a chemist, and as such he "looked at the

matter from a different point of view from that of the naturalists." Failing to find a trace of organic matter by analysis of the several specimens finally caught by John Murray, Buchanan suspected its inorganic nature and demonstrated that bathybius was nothing but an amorphous precipitate of sulphate of lime in spirits of wine and sea water.

Thus a great scientific idea came to an ignominious end. Graciously conceding that bathybius had been of some use, Buchanan declared in his report that it "should not be allowed to pass into oblivion." Indeed it should not, for science should remember its errors perhaps even more carefully than its successes. Although the *Challenger's* philosophers laid bathybius low, they were not immune from mistakes of their own, as Swire relates in his *Journal:*

> A wonderful new piece of clayey substance turned up in the analysing room, of whitish colour and having many remarkable peculiarities. It was found amongst specimens of the soils, etc., composing the islands of Bermuda, and as this particular substance had evidently not before been noticed by geologists and others as belonging to the Bermuda formation, the philosophers sat in solemn conclave, made an elaborate analysis of the strange stuff and sent home to England accounts of their great discovery. They were well satisfied with what they had done till, alas, one day a marine, prowling round the analysing room saw lying on the table an article which he at once recognized as a missing piece of pipeclay, his property, and took it away with him. No sooner did the philosophers miss the valuable substance which they had so long been puzzling over than they raised the hue and cry, when the story of course came out, and loud was, and is, the laugh against our learned men for this unaccountable blunder.

Achievements far outweighed blunders, however. In addition to settling the fate of bathybius, the *Challenger's* investigations included the first comprehensive analyses of the ocean bottom, demonstrating incidentally that chalk was not being laid down on the ocean floor by the shells of marine organisms. The pelagic character of many of the minute organisms of the sea, whose shells had been known only from bottom samples, was proved, and the fauna of the great depths was collected for the first time. Many had hoped for living fossils from the deep dredgings, but none was discovered, and the essentially contemporaneous character of deep-sea life with that of the shore and shallow sea soon was determined. The incidental fact that no traces of Atlantis were found did not discourage the ardent believers in that old tale of Plato's—mere negative evidence has never discouraged an antediluvian.

The sea-water determinations based on *Challenger* samples were so accurate that subsequent analyses have caused only minor corrections, and it can be said that the chemical nature of sea water was definitely established on this voyage. Many of the *Challenger's* most important results were published in British journals during the cruise. One of these reports prompted a humorous bit of doggerel in *Punch;* another, on preliminary temperatures, was the cause of an accusation against the scientific staff. W. L. Jordan, author of a semipopular treatise on hydrography and oceanography and possibly somewhat jealous of his colleagues, believed that the revised temperatures, based on later computations, were deliberate attempts to fit facts to preconceived notions and published a thirty-five page pamphlet to prove his case. It is true that the *Challenger's* thermometers were not as precise as those used today, but subsequent researches have supported the essential accuracy of the *Challenger's* temperatures, and Jordan's pamphlet is little more than a curiosity.

An unanticipated result of the voyage was the series of journals by various members of the expedition, which are useful sources of information about native life and manners on Pacific islands

and places which have changed beyond recognition in the seventy years since the *Challenger* visited them. All these journals were written during the cruise, but one of them was not published until 1938, when Herbert Swire's journal was handsomely printed by the Golden Cockerel Press at a de luxe price which has kept it out of reach of those who can best appreciate it. The journals by Moseley and Campbell, published shortly after the voyage, ran through several editions, and Moseley's book, stuffed with natural history and anthropology, is still kept in print, a standard item for libraries of scientific travel and exploration.

For such a long cruise, the *Challenger's* was comparatively uneventful: on the whole, it was a placid plodding around the world under sail (steam was used only for dredging and emergencies) at the leisurely speed of eight or ten knots. There was a close shave during a dangerous night on the edge of the antarctic ice and an unpleasant hour or two off Tierra del Fuego when the anchor struck a rock and broke, leaving the ship to drift toward a lee shore, and there were a few close calls with uncharted reefs, but that was all. The old reconverted warrior, with all her gunports, proved an unexpectedly comfortable and airy ship. Ten of the *Challenger's* original company of 243 died during the voyage, including a man lost overboard. Although rescued, he died shortly after. His rescuer, who had dived over after him as soon as the cry of "man overboard" was raised, was awarded the Albert Medal for his "most gallant action."

The most serious loss in the ship's company was the death from erysipelas of the young German naturalist von Willemoes-Suhm shortly after the ship left Hawaii. In the light of the subsequent careers of the rest of the *Challenger's* scientific staff, it is safe to say that von Willemoes-Suhm's name would have been eminent in zoology had he survived. Moseley became a well-known zoologist, one of the founders of the Marine Biological Association of the United Kingdom, teacher of several fine students of coelenterates, and the father of England's most brilliant physicist, whose death at Gallipoli was one of science' most grievous losses. Buchanan became oceanographer for the Prince of Monaco, while Murray's name became virtually synonymous with oceanography itself, and his researches earned him a knighthood.

WITH the completion of the voyage, the *Challenger's* work was just begun. The collections of plants and animals had to be sorted and sent to specialists, the chemical and physical data had to be checked and analyzed, and the reports seen through the press. The collections were deposited in the University of Edinburgh, and John Murray remained as Wyville Thomson's assistant to handle the material. When Thomson died in 1882, Murray fell heir to the *Challenger* material, and today it is his name which is remembered in connection with the voyage.

There is some justice in this, for, without Murray's personal fortune and unflagging interest in oceanography, the complete *Challenger* reports might never have been published. Murray financed many of the fifty folio volumes, which are the *Challenger's* monument, from the income derived from the development of the phosphate resources of Christmas Island in the Indian Ocean. He often said that the revenue to the Crown from this development, which was a by-product of his studies of ocean deposits, alone paid for the *Challenger* Expedition. Written by the authorities of the day, many of the *Challenger* reports are still the indispensable starting points for the study of marine life. This is especially true of zoology since so many new spe-

cies were brought up by the *Challenger*. There were other difficulties beside financial ones involved in the publication of the *Challenger* reports. An especially notable one is best appreciated from an explanatory slip which is attached to the title page of one of the volumes:

This is one of the copies referred to in the following Extract from the Third Report of the Controller of Her Majesty's Stationery Office, presented to Parliament in 1890:—

> The publication of the reports, by no means all of which, as your Lordships will recollect, were prepared in Great Britain or Ireland, has gone on without any mishap until a few months ago, when, unfortunately, a steamer carrying from Leith to London 306 copies of a volume then lately issued, was run into and sunk off the Lincolnshire coast. Among the damaged cargo afterwards recovered from the wreck and sold by auction by direction of the honourable Corporation of Trinity House, under the Removal of Wrecks Acts, 1877, were 13 cases containing about 190 of the lost "Challenger" volumes, in a more or less spongy state. These were bought back by the Stationery Office. They have since been taken out of the covers and dried, and it seems probable that from them, with the addition of new copies of some of the plates which happen still to remain on the stone, about 100 copies may be made up, stained, but for all practical purposes perfect. The copies thus made up will not, unless specially asked for, be issued for sale until the uninjured stock of the volume is exhausted. It is not impossible that in the eyes of future owners the imperfections of the recovered volumes may be compensated for by the knowledge that the books, like the "Alcyonaria" and "Polyzoa," which are beautifully figured in them, have been drawn from the bottom of the sea.

Their pages still taste of salt.

Finally, in 1895, nineteen years after the end of the voyage, the *Challenger Reports* were completed. The complete set of fifty volumes has since become a model for expedition reports, although few have equalled the *Challenger's* series in range of subject matter or completeness. There are volumes on zoology, botany, hydrography, bottom deposits, and the history of oceanographic research up to the time of the *Challenger* Expedition; and on that long row of big green volumes is based the modern science of oceanography. Their completion was just cause for celebration, and in commemoration of the event John Murray had a medal struck off and presented to each contributor; the contributors made up an album of their photographs for Murray, which was later published in facsimile as a souvenir.

Seven hundred and fifty sets of the reports were published. Today the sets repose in libraries all over the world, a constantly consulted monument to a great enterprise. As for the ship herself, she was decommissioned and turned into a coal barge. But the completion of the reports and dispersal of the scientific staff was not the end of the *Challenger* as a name in oceanography. Today much of the original collections, together with John Murray's library, is in the custody of the Challenger Society at the British Museum, which plays a leading part in directing oceanographic work in Great Britain.

Even in the *Challenger's* day, before the cruise was completed, other nations realized the importance of scientific research on the high seas, and several expeditions were fitted out. The *Challenger* had hardly begun her cruise before the Germans sent out the *Gazelle* for a two-year cruise. A few months after the *Challenger* returned, Alexander Agassiz began his active career in oceanography by directing the first cruise of the *Blake* in the waters of the Caribbean and Gulf of Mexico, and the Norwegians commenced their North Atlantic investigations in the *Vöringen*.

Still, after seventy years of deep-sea research, we have only made a beginning, and knowledge of the ocean, its life and physical characteristics, is more useful than ever. The war brought this out in many ways, for the Navy was confronted with problems as diverse as the effects of currents on life rafts in midocean and

the sounds made by fish and shrimp in submarine-detection devices. It is safe to say that the study of the oceans will be intensified in the next few years, for several governments are already planning investigations. The Danes have a ship ready for work off the African coast, and the U. S. Navy has just established a Division of Oceanography in its Hydrographic Office. Perhaps there will never be another such expedition as that of the *Challenger,* with her crew weighing anchor the first thing in the fresh morning of a new science. But the age-old challenge of the deep, which has stirred men of curiosity since the beginning of time, is still as strong as ever, and men still sail out to meet it. Certainly no research vessel can have a better name, and few can hope to gain as important a place in the history of science as did Her Majesty's Ship *Challenger.*

Sources of Information

In all, seven journals by members of the *Challenger's* company were printed, one of them as late as 1938, and another was reprinted in 1944. These and other items of interest (exclusive of the *Narrative of the Cruise* and *Summary of Results* in the *Challenger Reports*) are as follows:

Buchanan, J. Y.
''A Retrospect of Oceanography in the Twenty Years Before 1895.'' Address to the oceanographical section of the Sixth International Geographical Congress, held in London, 1895; revised and amplified. No. 2 in *Accounts Rendered.* Cambridge; pp. 28–86. 1919.

Campbell, Lord George
Log-Letters from ''The Challenger.'' London: Macmillan & Co. 512 pp. 1877.

Jordan, W. L.
The Admiralty Falsification of the ''Challenger'' Record. Exposed by William Leighton Jordan, &c. London: Spottiswoode & Co. 35 pp., chart. 1890.

Moseley, H. N.
Notes by a Naturalist. An account of observations made during the voyage of *H.M.S. Challenger,* &c. A new and revised edition, with map, portrait, and woodcuts and a brief memoir of the author. London: John Murray. xxiv + 517 pp. 1892. (Reprinted by Laurie, London. 540 pp. Illus. 1944.)

Spry, W. J. J.
The Cruise of Her Majesty's Ship ''Challenger.'' Voyages over many seas, scenes in many lands. New York: Harper & Bros. xvii + 388 pp. 1877.

Swire, Herbert
The Voyage of the Challenger. A personal narrative of the historic circumnavigation of the globe in the years 1872–76 by Navigating Sublieutenant Herbert Swire, R.N. Illustrated with reproductions from paintings and drawings in his journals. Foreword by Major Roger Swire, R.C.R.E. Introduction by G. Herbert Fowler, C.B.E. London: Golden Cockerel Press. 2 vols., folio. 1938.

Thomson, C. Wyville
The Atlantic. A preliminary account of the general results of the exploring voyage of H.M.S. ''Challenger'' during the year 1876. New York: Harper & Bros. 2 vols. 1878.

Wild, J. J.
At Anchor: a Narrative of Experiences Afloat and Ashore During the Voyage of H.M.S. ''Challenger'' from 1872–67. London and Belfast: M. Ward & Co. 198 pp., 13 col. plates. 1878.

Willemoes-Suhm, Rudolf von
Challenger Briefe. Leipzig: Verlag von Wilhelm Engelman. xii + 180 pp. 1877.

THE LAST CANUTE

By GARRETT HARDIN
SCIENCE DEPARTMENT, SANTA BARBARA COLLEGE

The editors of the MARTIAN MORNING REVELATION are proud to present to their readers another exclusive REVELATION revelation. The following document was found engraved on stainless steel plates which have only recently been uncovered near the site of Worldly New York. With the discovery of these plates we have, for the first time, found evidence that at least a few Worldlings tried to fend off their doom. . . . What a strange quirk of Fate that these people, who titillated themselves with visions of catastrophic destruction by atomic power —which to these primitive folk seemed a wondrous thing—should instead have perished peacefully, inexorably "suffocated," as one of their prophets put it, "by their own intellectual excreta."

Last Meeting of the Board of Trustees of the New Alexandrine Library Fund

January 20, 1955, at 1500.

THE meeting was opened by Mr. Gregory Adams, Chairman. The minutes of the previous meeting were read and approved. The treasurer's report was read and approved. There being no further routine business, the chairman proceeded to a summing up of our activities.

Mr. Adams. Gentlemen, this is a melancholy occasion. We are gathered today, only a little more than two years after the beginning, to give the *coup de grâce* to the New Alexandrine Library Fund. The aims of Mr. Babcock, the founder, have not only not been carried out, they have been completely thwarted. Eighty million dollars thrown to the winds! Think of it, gentlemen.

It seems to me that we ought to have a ceremony of some sort, but I don't know exactly what. You lay a cornerstone when you begin a building, cut a string when you open a road. But what do you do when you bury a dream? What sort of ceremony is appropriate?

Perhaps the most suitable thing we can do is make the minutes of this, our last meeting, a sort of memorial to this dream. With that thought, I should like to read into the minutes a brief résumé of the life and death of the New Alexandrine Fund. You all know it as well as I, but if you will bear with me—perhaps correct me and add to the record——. It will be a sort of wake——.

Just exactly where one should begin the story of Chauncey Babcock and his dream I'm not sure, but I believe it began about ten years ago when the librarian of one of the small Eastern colleges wrote a book in which, among other things, he pointed out that at the present rate of growth the Yale library, as an example, will, in the year 2040, contain two hundred million volumes occupying six thousand miles of shelves and will require a staff of six thousand librarians to do the cataloguing alone. I believe those were the figures. At any rate, the author proposed as a solution to this problem that libraries should change from full-size books to microbooks, books photographically reduced to a fraction of their original size. Similar proposals, differing only in details, were made by other scholars and scientists, some of them proposing perfectly fantastic gadgets for housing and using microfilm. It was thought that since microfilm took up so little space, the whole storage problem would vanish.

It was at this point that Mr. Babcock became interested in the problem, and, although he was a businessman rather than a scholar, his native common sense permitted him to see the fallacy of the proposed solutions. Simply stated it is this: you cannot by any means of compression solve the problem of storing a pile of documents which is growing without limit. You can merely delay the day when the problem becomes spatially embarrassing. Instead of that day coming in two centuries, it may come in two millennia. But ultimately the day of reckoning must come.

To suppose otherwise is absurd, as though

one supposed that since mice—to take an example—are individually very small animals they will never take up much space no matter how much they reproduce. But we all know that any organism, no matter how small, will finally occupy the entire universe if it continues to multiply unchecked. In the long run, it isn't the size of the individual that is important; it is the growth rate of the population. In nature, the fecundity of plants and animals is opposed by various causes of mortality, so that the net growth rate of most populations at most times is zero. In man's libraries, on the other hand, there is a quite different situation. Here, apparently, there is no death, only birth. The number of library books doubles six times a century. How big those books are is a matter of only evanescent importance.

Mr. Babcock realized that no real beginning can be made in the solution of the problem until librarians begin to destroy their books. Libraries must have a well-thought-out system for getting rid of books, as they have for acquiring them. This seems obvious enough—to everyone but a librarian. His profession is getting and keeping books, storing them and holding them. As a result he has, with very few exceptions, the magpie's instinct developed to an exceptional degree. Whether the profession tends to select the person who has this hypertrophied instinct in the first place or to develop it in him after he enters the ranks, I don't know. Probably a bit of both. The end product is the same: a magpie, a pack rat. So strong is his impulsion to collect that one cannot even discuss with him the possibility of un-collecting and expect to receive a rational answer. Consider yourself lucky if your suggestion evokes nothing more violent than the cold, glassy stare of the outraged professional man.

Plainly, some books and documents must be destroyed. But how persuade librarians of this? That was the problem Mr. Babcock faced. Weeding out had been proposed by laymen a good many times, but the proposal always met with the most bitter scorn. What was needed was some way to force or persuade the librarians to accept it. Mr. Babcock's great contribution to learning and civilization was the discovery of a way. That it failed is almost incidental. It was a good idea. If the loopholes are plugged I think it may yet work, if given another chance.

Between 1945 and 1951, when he wrote his will, Mr. Babcock did a good deal of snooping around libraries, investigating librarians, and questioning the users of libraries. Talks with scientists revealed one curious aspect of libraries, namely, that the more worthless books become for the scientist, the more valuable they are in the eyes of the librarian. Take, for instance, the field of genetics. Before Mendel, there were veritable libraries of books on heredity—Gaertner, Koelliker, Naudin, Koelreuter, to mention only a few of the scores of authors. Yet with the publication of Mendel's forty-page paper all these other tens of thousands of pages became utterly useless. Today, no one who wished to learn the facts of heredity would dream of consulting Gaertner or Koelreuter. As a matter of fact, he wouldn't even look up Mendel's obscure paper, for the essence of its forty pages can, without loss, be neatly stated in two. Yet, do the libraries throw away any of their copies of Gaertner and Koelreuter? On the contrary! Any "normal" librarian would trade a hundred books of 1955 science for one musty, useless volume written by Gaertner and consider that he'd made a fine bargain. Librarians often justify the size of their elephantine institutions by pointing to the ever-increasing growth of science and of scientific publications which they must store. But science, ever-expanding though it is, is at the same time ever-contracting. It requires the expenditure of years of work and the publication of thousands of scientific papers to arrive at a single great generalization. When you look at the situation from the other end, you see that each great generalization makes obsolete and valueless tons of research reports that were spewed forth on the way. Scientists are aware of this fact; librarians seem not to have been informed of it.

Rambles through library stacks led Mr. Babcock to another discovery. He found that, quite aside from "source" works, for whose preservation there are ready-made rationalizations, there is a much larger mountain of derivative works—textbooks and like compendia—for which there is no excuse other than timeliness. Mr. Babcock was struck with the spectacle of the tons of old textbooks that clutter up libraries quite uselessly. Take down any student text dated 1900 and you will likely discover from its

record sheet that, although it was much used for the first five years, it was last drawn out about 1910. It has been sitting idle on the shelf for the past forty-five years and bids fair to be sitting there still on Resurrection Day, barring termites, fire, floods, earthquakes, and bombings.

Mr. Calhoun. Incidentally, the mention of termites reminds me of a story which none of you, I believe, except Mr. Adams has heard before. It was told to me by Mr. Babcock not long before his death. It seems that one day, permit in hand, he was browsing around in the basement of the main library of the University of Chicago when he discovered a young man pulling away some rotten wood from an old and much-patched wall. Mr. Babcock became curious and asked the fellow what he was doing. He turned around and looked Mr. Babcock squarely in the face for perhaps five seconds, thus assuring himself that his interrogator did not have the physical conformation of a librarian, then explained: "I'm taking some of this wood for use in a zoology course. You see, there's a good termite colony here, and we need termites to illustrate Serial Homology and Convergent Evolution. We get them from here every year."

"But," said Mr. Babcock, "doesn't the library know about this? These termites could do a lot of damage, couldn't they?"

"I don't think so. It's too far north for them to really thrive. At any rate, when I'm through I'll put in a new board where I took out the old one so as to keep the colony going. If you'll notice," he said, pointing to the variegated wall, "this has been going on for a good many years, and they don't seem to have started on the books yet. It's an unwritten rule that each new zoology assistant shall show his appreciation to the Harper termites by putting in a new piece of wood and will not tell the librarian about the colony. We hope that you, too, will respect the tradition, sir."

Mr. Adams. Yes, that's right. I might add that Mr. Babcock even toyed with the idea of establishing an eighty-million-dollar termite hatchery, but gave it up on advice of a distinguished termitologist.

(Laughter.)

And that brings us to another, and perhaps the most curious element of the whole library picture, namely, the librarian. As I have intimated, years of tending books have made him more interested in the conservation of knowledge than in its dissemination. Discovery of this truth was quite a shock to Mr. Babcock, who had innocently supposed the contrary. He found, for instance, that librarians are pretty generally opposed to replacing books that are stolen, on the curious ground that the replacements will likely be stolen, too. They tend, though perhaps unconsciously, to buy unpopular books for this reason, though they never call them unpopular, of course; they call them "scholarly." As you can see, if popular books are stolen and not replaced, and unpopular ones are left unmolested on the shelves, the result is natural selection working in favor of the worst books. In relative terms, as the library gets older and bigger, it gets worse and worse. But no librarian will consider remedial measures.

Mr. Falconer. I think you do librarians some injustice there. Admittedly, many of them are simply bibliophilic pack rats, but there is an appreciable minority that is quite aware of what's going on. Suppose a librarian decides to weed out the deadwood, how is he to do it? Is *he* to take the responsibility alone? After all, each field requires its own experts to do the judging. What is needed is better liaison between the library and the rest of the departments. Some small institutions actually have a weeding-out system. The situation is usually worst in the larger places where the departmental walls are highest and the art of evading responsibility developed to the highest degree. The librarian in a large institution may be quite amenable to the idea of a book-purge, but he can find no one to take the responsibility of naming the books.

Mr. Adams. I think there is some truth in what you say. Perhaps it is not men but the system that is at fault. Whatever the cause, Mr. Babcock proposed to use his money to try to remedy the situation. He knew that a mere eighty million dollars wasn't much, but he thought an humble beginning might be made, that a little money properly spent might have an immense moral effect. Hence the terms of his now famous will: Twenty million dollars available to the libraries of Harvard, Columbia, Chicago, and Stanford, on condition that for each $10.00 they applied for, one book of at least five hundred

pages must be removed forever from the stacks and destroyed. Yale University was also originally scheduled for a share of the Fund, but in the end it was decided to keep the Yale library as a control.

Of course, there had to be a lot of legally complicated conditions designed to prevent the libraries' acquiring duplicates of the very books discarded, which they might very well do, for librarians have collectors' morals. But the mechanics of selecting the books to be discarded were left to the discretion of the beneficiaries.

Well, we know the reaction when Mr. Babcock died and the terms of the will became known. The four great universities simply exploded. On the one hand, there was pressure from the alumni and the trustees to accept the money, and on the other there was the hysterical refusal of librarians to commit such an unnatural crime. Cries of rape and pandering, sacrilege and desecration, filled the air. There were threats of resignation and counterthreats of acceptance. One library employee actually did resign—he was a fifteen-dollar-a-week stack-boy at Harvard, who did so at the request of the head librarian. It was intended as a show of force. The example was not followed by others.

Finally, at Stanford, where the need for funds was most desperate, there came an offer of arbitration. They announced that they were willing to live up to the terms of the Fund, provided the provisions were made more generous. Whereas, they said, it cost $1.23 to accession an incoming volume, they estimated it would be impossible to remove a book for less than ten times that amount, on account of the clerical problem of rooting out all the cross-index entries, etc. We felt that their accounting was dubious but rather than be diverted to chasing that sort of red herring we used our powers as trustees and raised the ante to $20.00 a volume. The librarian's letter of acceptance of the new conditions was overwhelming in its unenthusiasm. Nevertheless, Stanford went ahead with the program. Six months later the librarian announced that he was sending us ***seventeen*** books for destruction, and would we please forward the library a check for $340.00 so the program could continue at full speed? It was only a modest beginning, certainly, but at least it was a beginning. It began to look like we might get somewhere. And then—*the Harvard suit.*

Looking backward now, it seems rather surprising that as astute a businessman as Babcock did not foresee this argument. None of us here foresaw it—but we aren't Babcocks. It was a childishly simple argument, this invention of the Harvard Law School, but it was watertight.

A personal bequest cannot be made on condition that the beneficiary extirpate part of his person. You can't leave your nephew a million dollars on condition that he have his nose cut off. He gets the money without meeting the condition.

Harvard pointed out that a university is a legal person. Asking it to destroy part of its library is like asking it to destroy part of its person—ergo——. They have carried their case all the way to the Supreme Court and yesterday, as you know, they won the final round. We have been ordered to hand over the eighty million dollars to the four universities, *unconditionally.*

And that, gentlemen, seems to be that.

(There was a long pause.)

Mr. Falconer. Well, I guess we fold our tents. That's all, isn't it?

Mr. Adams. Oh, we have a couple of million in miscellaneous to dispose of.

Mr. Hungate. What shall we do with them?

Mr. Falconer. Isn't there some sort of gesture we could make with the money? Like setting up a foundation for the promotion of illiteracy?

(Laughter.)

Mr. Adams. Gentlemen, this isn't a funny occasion. Let's not make fools of ourselves. Something sensible now. This is a tragic occasion, and it ill befits us to behave otherwise.

Mr. Bell. Tragic is an understatement. Where in God's name will it end? Our libraries are doubling in size every sixteen years. There is no record of a human population continuously doubling in less than twenty-four-year intervals, and few have even approached that. Our own population is practically stationary now, but the multiplication of books continues unhindered. We won't even be able to store the index cards that tell where the books are. In 2040 A.D. the Yale library will need six thousand cataloguing librarians. If you continue the cal-

culations you find that a century later this one library will need 384,000 cataloguers. Another century and the figure is 23,000,000. Presumably, Harvard, Columbia, Princeton, Texas, and California and all the other big libraries will have grown in a similar way. Are we all to end up in the card-index room of a library? If everyone is cataloguing books, who on God's green earth is going to write them? I don't mean that would be a great tragedy, of course. But if all the world is covered with books and card indexes, where is man to live?

Mr. Calhoun. While we all have our hair down, I have four clippings from the morning paper which you may not have seen and which I'd like to read into the record. No, I won't read them, either; they all say the thing three times over, as newspapers always do. I'll just give you the gist of them.

First, here's a dispatch from Chicago which quotes the librarian as saying that during the next ten years the University of Chicago expects to acquire one million more volumes than it would otherwise have been able to, thanks to the thoughtful generosity of Mr. Babcock. The librarian goes on to say: "We expect to put our greatest efforts into strengthening the library of the Graduate Library School, buying upwards of 100,000 volumes in the field of library science."

Second, a report from Stanford. The librarian there says, and I quote: "As a result of the farseeing bequest of Mr. Babcock we shall be able immensely to strengthen and improve our accessioning and indexing system. At the present time we are struggling along on a mere $1.37—" it's gone up, I see—"1.37 a volume. The new bequest will permit us to institute the improved A.L.A. system, which will run the cost to around $5.00 a volume."

Mr. Hungate. It looks to me like Mr. Babcock overlooked something. He should have subsidized a series of research fellowships in librarianship, the fellows' efforts to be spent in devising new and improved systems of accessioning. In twenty years or so we could reasonably expect the "best" system to be so supercolossal and expensive that no library would be able to afford to acquire and accession another volume. Result—no more books acquired, no more problem.

(Laughter.)

Mr. Calhoun. Next, a report—you'll love this—from Columbia. Columbia has managed to purchase, for a mere $50,000, Professor Bumblebucher's entire collection of essays written by New York school children during the years 1930 to 1950 on the subject "What George Washington Means to Me." Accessioning this magnificent collection will cost an estimated million dollars. The dean of the Teachers College estimates that they should be able to squeeze at least thirty-five Ph.D.'s out of the material.

But perhaps the prize of all is a two-column article from Harvard on *their* plans. After a preamble in which the librarian tells what a tremendous problem theft is in a university library—Harvard, for instance, lost some 1,800 volumes last year, aggregating in value more than $15,000—he outlines their plans for stopping this disgraceful leakage. Books are to be made virtually inaccessible, of course. No stack permits to faculty members of whatever rank. All library workers to be bonded. No brief cases, notebooks, overcoats, pens, pencils, or paper to be permitted in the library, and no books to circulate. All books will be given a special coating of a radioactive material on the backbone, just under the cover. Exit from the library will be only through turnstiles guarded by Geiger-Mueller counters which will indicate the proximity of radioactive material by ringing a fire-alarm bell. The installation expense for all this Goldbergiana is estimated at $5,000,000, and the yearly maintenance at $150,000. It is expected to completely eliminate losses of books.

Mr. Bell. Oh, Christ.

(Silence.)

Mr. Bell. Since we seem to be through, I'd like to suggest that the board adjourn to my apartment where, in honor of the occasion, there have been gathered virtually unlimited supplies of Pilsener and Chateau Wente '47.

Mr. Adams. There being no objection—?

Mr. Hungate. How about the Red Cross? Let's give the two million to the Red Cross.

Mr. Adams. Is that agreeable with everyone? Very well, so be it.

Mr. Calhoun. Just a minute. I have an idea. You said, Mr. Adams, that you

thought that the minutes of this last meeting should be a sort of memorial, and so you read into them a history of the New Alexandrine Library Fund. How about making use of this memorial? Say, have these minutes hand-lettered on parchment, four copies, and send one to each of the libraries?

Mr. Bell. Gruesome, but I'm for it.

Mr. Hungate. At the same time, better appropriate a ten-thousand-dollar gift to each university for accessioning the document.

(Laughter.)

Mr. Adams. It is so ordered.

Mr. Falconer. Do we want the complete minutes done that way, including the reference to the wine and beer?

Mr. Bell. Damn it, yes. Including everything.

(Laughter.)

Mr. Calhoun. Hold on. I don't think we ought to let Chicago know about the termites. I move that all reference to the termites be expunged from the memorials. Those termites are our only remaining hope.

(No laughter.)

Mr. Adams. It is so ordered.

The meeting was adjourned at 1545.

The parchment manuscripts referred to on the plates have not been found, nor, in view of the peculiar end of the Worldly civilization, does it seem likely that they will ever be uncovered.

THE EAR OF DIONYSIUS

"All-seeing Eye"—but why the Eye,
  And not the Ear all-hearing?
Speed the thought, it made him spry—
  Dionysius a tyrant being.

Demanded he an Ear Immense
  For hearing avaricious.
In stone it grew through season tense,
  "The Ear of Dionysius."

It caught what eye could never gain,
  Nor missed the slightest stirring;
It picked the thoughts from Plato's brain—
  And packed him off demurring.

Since when the Ears wise men disprize:
  The fruits they yield are *rumors.*
Knowing ones prefer bright eyes;
  For eyes are moist with humors.

T. V. Smith

RELATIVE COOLING REQUIREMENTS FOR AMERICAN HOMES

By STEPHEN S. VISHER
PROFESSOR OF GEOGRAPHY, INDIANA UNIVERSITY

IN MORE than half of the United States outdoor temperatures are high enough during considerable periods to make house cooling distinctly desirable. The regional contrast in the duration of hot weather and its intensity is an aspect of climate that is becoming interesting to an increasing fraction of our people who hope to air-condition their homes.

The present article is a summary of some official data on high temperatures. It is a companion to the article on heating requirement contrasts in THE SCIENTIFIC MONTHLY for October 1945. It is less adequate than that article because data on high temperatures have been less thoroughly studied. This relative neglect of high temperatures is a natural consequence of the fact that house heating is indispensable in much of America, whereas house cooling is not. When houses are too warm, our health is not endangered; we merely feel uncomfortable and accomplish less work. Moreover, even crude shelters can be rather simply heated, whereas cooling requires expensive equipment and costly buildings.

Much evidence indicates that human efficiency declines at temperatures above 70° F. Indeed, some data assembled by Ellsworth Huntington and others suggest that for intellectual achievement the optimum temperature is below 65°.

Data on high temperatures of several sorts are available: (1) the highest temperatures ever officially recorded (the absolute maxima); (2) the average annual and monthly maximum temperatures; (3) the average daily maximum temperatures; (4) the normal, or mean, daily temperatures, computed by averaging the highest and lowest temperatures experienced; and (5) the average duration of high temperatures. Under this fifth category several aspects of high temperatures may be considered, such as the number of days when the maximum is above 90°, the number of days when the average of day-and-night temperatures is above 80°, the number of nights when the temperature does not fall below 70°. Finally, (6) of special interest from the standpoint of cooling requirements is the average number of "hot degree-day units." A day with an average day-and-night temperature of 71° has one such unit; a day with an average temperature of 75° has five such units; one of 85° has 15 such units. This "hot degree-day unit" is the converse of the "cold degree-day unit" discussed in the October 1945 article. Hot degree-day units have not been assembled by the Weather Bureau, which has done considerable work on the cold degree-day units, chiefly by, or under the direction of, J. B. Kincer. I have worked out average hot degree-day units from data on "Mean Daily Temperature Normals."

A map showing the highest temperatures officially recorded in the United States was given in "Temperature Contrasts in the United States," THE SCIENTIFIC MONTHLY for September 1942. There also were published maps of the average annual maximum temperatures and the average July temperatures. Hence, despite the relevancy of these maps to the present discussion, they are not reproduced here. The following descriptive summary requires so little

space, however, that it is justified. The whole country has had temperatures in excess of 100° except small areas in the mountains, along the northern Pacific Coast, in the Northeast, and in southern Florida. About three-quarters of the country has been hotter than 105°; nearly half of it has been hotter than 110°. In each of 20 states one or more localities have had maxima in excess of 115°, and five states have local records higher than 120°. (The national record is 134° in California, followed by 127° in Arizona and 124° in Nevada.) In the average summer the thermometers rise in about half of the country to 100°, and in about a fifth they rise to 105°. In the average year temperatures in excess of 110° are found chiefly in the arid Southwest (western Arizona, southern Nevada, and southeastern California). About four-fifths of the country has a July day-and-night average in excess of 70°, almost two-fifths has an average above 80°, and parts of Texas, southeastern California, and western Arizona have July averages of more than 85°.

Map 1 shows the number of days per normal year when the daily maximum temperature reaches or exceeds 90°. It reveals that nearly one-fifth of the country has fewer than ten such days, another fifth has more than 60, and a sizable area in the South and Southwest has more than 100—parts of it more than 140. (Yuma, Ariz., has 164 such days and 96 days of 100° or more.) This original map is based on the records of many regular Weather Bureau stations as presented in the official summaries to 1944, supplemented by deductions from "Average Daily Maximum Temperatures 1916–1935" (official, mimeographed, 1944).

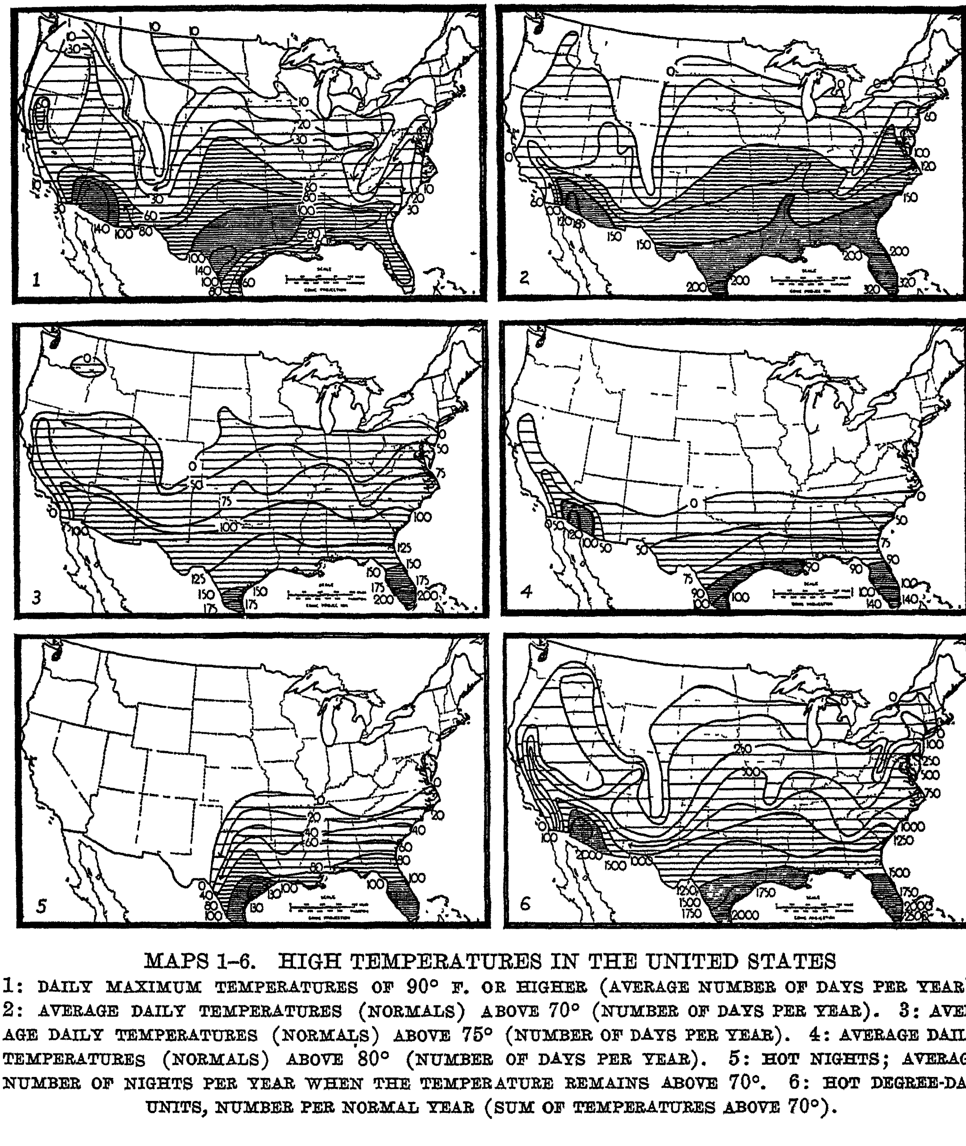
Map 2 indicates the average number of days per year having daily normals (average of day and night) above 70°. The middle of the country north and south has about 100 such days, whereas the northern border and most of the Pacific Coast have none. By contrast, near the Gulf of Mexico nearly 200 days have normals above 70°; southern Florida has more than 300 such days. This original map is based on the data given in the official "Normal Daily Mean Temperatures" (Supplement 25, Monthly Weather Review).

Map 3 shows that very hot weather (day and night averaging 75° or higher) is lacking in approximately a third of the country, but that it is normal for more than four months along the Gulf Coast. (This map is new; same source as Map 2.)

Daily normals above 80° (Map 4) are almost restricted to the southern states and the Great Valley of California. Southern Texas and most of Florida have more than 90 days averaging above 80°. (This map is new; same source as Map 2.)

When the nights are relatively cool for several hours, permitting restful sleep, more daytime heat can be successfully withstood than when the nights are hot. Map 5 shows the number of nights per average year when the temperature does not fall below 70°. This map supplements the foregoing ones by indicating large contrasts in the need for air conditioning. It reveals that along the Gulf Coast there are about 80 such enervating nights per year, while in southern Florida there are more than 100 (111), and in part of southeastern Texas as many as 135 such nights. Map 5, new, is based on data deduced from the official "Average Daily Minimum Temperatures 1916–1935."

Map 6 presents the average annual number of hot degree-day units (total degrees above 70° times the number of days, derived from the daily normals). It reveals that the northern and western



MAPS 1–6. HIGH TEMPERATURES IN THE UNITED STATES
1: DAILY MAXIMUM TEMPERATURES OF 90° F. OR HIGHER (AVERAGE NUMBER OF DAYS PER YEAR). 2: AVERAGE DAILY TEMPERATURES (NORMALS) ABOVE 70° (NUMBER OF DAYS PER YEAR). 3: AVERAGE DAILY TEMPERATURES (NORMALS) ABOVE 75° (NUMBER OF DAYS PER YEAR). 4: AVERAGE DAILY TEMPERATURES (NORMALS) ABOVE 80° (NUMBER OF DAYS PER YEAR). 5: HOT NIGHTS; AVERAGE NUMBER OF NIGHTS PER YEAR WHEN THE TEMPERATURE REMAINS ABOVE 70°. 6: HOT DEGREE-DAY UNITS, NUMBER PER NORMAL YEAR (SUM OF TEMPERATURES ABOVE 70°).

borders of the country and the high western mountain region normally lack hot degree-day units. By contrast much of the southern part of the country has more than 1,000 such units and the southern parts of Florida and Texas have more than 2,000 units.

Map 6 indicates a sharp southward increase in the need for cooling. For example, New York City has about three times as many hot units as New Haven; Philadelphia, nearly twice as many as New York; Washington, a fourth more than Philadelphia; Atlanta, more than twice as many as Washington. Similarly, Cincinnati has nearly four times as many hot units as has Detroit; St. Louis, about twice as many as Cincin-

nati; and Memphis, almost twice as many as St. Louis. The cities on the Pacific Coast have no hot units except Los Angeles (the main part of which, including the Weather Bureau station, is some 20 miles inland), which has 45, the same number as Erie, Pa.

A seventh map, not published here, portrays the average number of hot degree-day units during the nine cooler months, September to May, inclusive. It reveals that more than half of the country does not have any daily normals above 70° during most of the year. Conversely, the southern states have more such hot days in spring and fall than most of the North has in summer. The southern parts of Texas and Louisiana and most of Florida have more than 500 hot degree units in spring and fall (Key West has 1,463); southwestern Arizona and the nearby part of California also have more than 500 units, Yuma having 730.

These maps, based on official data, reveal sharp regional contrasts in the intensity and duration of high temperatures and hence the need for artificial house cooling, if maximum comfort and intellectual activity are to be attained. The South and the arid Southwest are conspicuously hot except on the coast. The dry heat of the arid region is notably less enervating than the "sticky heat" of the humid South. The humidity of the South not only renders high temperatures more trying but it makes air conditioning distinctly more difficult. When moist hot air is cooled, condensation is induced. Insofar as the relatively mild winters in the South encourage the construction of poorly insulated buildings, artificial cooling in hot weather is rendered less efficient.

A FULL UNIVERSE

EDWARD ROSEN

To TRACE the history of a fundamental idea through its encounters with rivals and opposites, to analyze its modifications and progeny, its allies and its enemies, its spread and decline, is a fascinating enterprise requiring philosophical acumen and wide learning. A splendid example of this newer type of historical investigation was provided by Arthur O. Lovejoy's penetrating study of a decade ago, *The Great Chain of Being,* which focused its attention on Plato's fecund doctrine of the full universe—christened "the principle of plenitude" by Lovejoy. The plenitudinarians, or plenists, saw in the realm of nature a vast ladder reaching down to the lowliest forms of life and rising rung by rung through progressively diminishing degrees of imperfection to that crowning glory of creation—mankind. Upon this ladder of natural beings otherworldly minds superimposed a hierarchy of disembodied spirits, ranging through various gradations of Intelligence to the Highest Good, for those of a metaphysical or mystical bent, and for those of a theological persuasion, through ascending orders of Blessedness to the Highest God. This organization of the sensible or supersensible world was mirrored in the structure of society, which comprised men and women of every level, from the humblest laborer toiling at a menial task to the most exalted dignitary. There were no gaps, no chasms; every potential type of existence was actualized. Like a nation with a housing shortage, the universe was full.

The principle of plenitude long dominated astronomical thinking, too, in a way that somehow escaped Lovejoy's vigilant eye. It may be instructive to trace the fortunes of this ascendancy, from its rise in the Greco-Roman world of antiquity to its collapse in the Renaissance, when the age of unaided naked-eye observation was drawing to an unlamented close.

We may begin our little history with Claudius Ptolemy, in whom man's persistent effort to discover the pattern of the cosmos attained, by common consent, its first great culmination. The Platonic principle of plenitude united with the Aristotelian concept of continuity to produce a vision in Ptolemy's mind of a tightly-knit universe with no empty space. In his major work, the *Syntaxis* (long known, by reason of Arabic adulation, as the *Almagest*), he attempted to ascertain the maximum and minimum distances of the sun and moon from the earth by the method of parallax, which is still the principal avenue of attack on this problem. Although his values for the sun were far too low, in the case of the moon his numerical results were astonishingly good. But however accurate or inaccurate his conclusions may have been with regard to the sun and moon, the method itself was inapplicable to the planets since, as he sadly admitted, "none of them shows a perceptible parallax, the only phenomenon by which the distances are determined."

What sort of picture of the universe, then, confronted the diligent reader of the *Syntaxis?* He knew (or thought he knew) how far from the earth the sun and moon were; but, as for the planets, only their relative distances were disclosed, and it was acknowledged besides that no observational means were available to compute the exact distances. Thus the powerful human craving for an answer to the question "How far?" was

left unsatisfied. Even Ptolemy must have felt the tug of this frustration, for in a subsequent work he adopted a non-observational approach.

In the *Hypotheses of the Planets* he rejects Plato's arrangement of Mercury and Venus above the sun with the following application of the principle of plenitude to cosmic space:

> Mercury and Venus must be located not above the sun, but between the sun and the moon, lest this space, which is so vast in accordance with appearance and also with our conclusions about the distances, remain empty, as though nature had forgotten and neglected it, and hence made no use of it. Yet it is capable of encompassing the distances of both the above-mentioned planets, which are nearer than the others to the earth, so that this space is exactly filled by the two planets alone.

Ptolemy advanced this argument only to support his contention about the relative distances of the inferior planets, and there he let the matter rest. But his words carried an implicit suggestion which was seized upon by later generations. Had not the prince of astronomers said that Mercury and Venus *exactly* fill the interval between the sun and moon? Did this not imply that Mercury's least distance from the earth—its perigee—must be equivalent to the moon's greatest distance from the earth—its apogee? By the same token, must not the sun's perigee equal Venus' apogee? But the lunar apogee and solar perigee were perfectly definite numerical quantities, for Ptolemy had measured them in terms of radii of the earth. Well, then, the perigee distance of Mercury and the apogee distance of Venus were known, too. The riddle of the planetary distances was beginning to yield before the onslaught of the plenists.

They now opened the second phase of their offensive. If there is indeed no empty or unused space in the universe, then of course Mercury's apogee must be identical with Venus' perigee. To be sure. But how could one fix the line of demarcation? This difficulty was overcome by utilizing the relative dimensions of the circles whose combined action, according to the *Syntaxis*, produced the orbit of each body. The ratios which Ptolemy had computed for these circles were an integral part of his planetary theory. But that theory had itself been modestly designed to represent, in the closest possible agreement with observational data, the angular motion of the planets without regard to their actual distances. Thus, the end product of a series of purely geometrical calculations was joined with entirely independent observational results, under the auspices of the principle of plenitude, to furnish a supposedly accurate determination of the maximum and minimum distances of Mercury and Venus.

The unfolding of this procedure can be studied in the pages of Proclus, who succeeded to the leadership of the Neoplatonic Academy in the fifth century A.D. Proclus wrote an elementary introduction to Ptolemy entitled *Hypotyposis*, or *Outline*. At the end of this book he summarized his results in a series of conclusions, among which we find:

> The seventh concerned the disposition of the planets, which has been discussed in an earlier section. Now some people, relying on the perigees and apogees, conclude that the lunar apogee nearly coincides with the perigee of Mercury, as does the apogee of Mercury with the perigee of Venus, and the apogee of Venus with the solar perigee, so that the order of these bodies with respect to one another is revealed by these relationships.

After citing Ptolemy's numerical determinations for the sun and moon, the neoplatonic philosopher-mathematician reports that the same unnamed persons, "assuming that there is no empty space in the arrangement of the universe . . . undertook an examination of the apogees and perigees of Mercury and Venus to see whether these could fill out the aforesaid numbers." Through the use of Ptolemy's ratios for the constituent cir-

cles in the theory of these planets, the line of demarcation between Mercury and Venus was established. Proclus closes a similar passage in his *Commentary on Plato's Timaeus* with these words:

> Clearly, the spheres of Mercury and Venus must be placed between the moon and the sun. For the moon's greatest distance coincides with the least distance of Mercury; Mercury's greatest distance with the least distance of Venus; and the greatest distance of the latter with the sun's least distance, almost exactly. For there must be no empty space."

The prestige of the plenists was heightened in the following century by the (mistaken) assertion of Simplicius in his *Commentary on Aristotle's De Caelo* that the details had been worked out by Ptolemy in the *Syntaxis*. Thus, according to the most influential commentator on the greatest philosopher, the foremost astronomer in his major work had obtained observational data in agreement with deductions from an a priori principle. What more could anyone ask?

Beneath this analysis lies a conception of the physical universe which may be likened to a succession of grapefruit rinds or layers of onion skin. The inner surface of the rind represents the perigee distance of the planet, and the outer surface corresponds to the apogee. As each planet moves on its majestic course, it will always be found somewhere within its heavenly rind. The outer surface of each rind fits snugly within the inner surface of its next larger neighbor, and the entire universe consists of a small number of such rinds, or spherical shells, from the innermost center to the outermost surface, the flaming ramparts of the world.

When intellectual hegemony passed from the declining Greco-Roman civilization to Islam, the Muslim scientists in the main founded their cosmology on Ptolemy's system. Accepting the principle of plenitude, they extended its application by parity of reasoning from Mercury and Venus to the remaining planets and the fixed stars. From their labors there emerged a cosmos whose dimensions were known throughout. This tidy and comforting notion was diffused from the Arab centers of learning to the West when interest in scientific questions revived. For centuries the principle of plenitude ruled supreme without any serious challenge.

THE long reign of the Ptolemaic cosmology faced its first major upheaval when Copernicus subverted the established order of the planets. But his transfer of the sun to the central position and his identification of the earth as a planet wandering in the middle reaches of cosmic space entailed a huge outward thrust of the uppermost spherical shell, the region of the fixed stars. For as the earth traverses its annual orbit about the sun, it should produce an alteration in the apparent position of any fixed star. If this is noted of a clear night and then again six months later when our mobile observatory, the earth, has swung round to a diametrically opposite point on its yearly circuit, the star should appear to have shifted somewhat in the meantime. For, although the star itself may have remained constant, the line of sight now approaches it from an altogether different direction. And yet no such annual parallactic shift could be observed, for it is too minute to be discerned with the unaided eye. To account for its absence, Copernicus was constrained to postulate an enormous remoteness for the fixed stars. Between them and Saturn, the highest of the planets, yawned a vast emptiness. What could possibly serve as filling for this immense gap? The rumbling produced by this insistent question caused the principle of plenitude to totter on its shaky throne.

Tycho Brahe, the last great naked-eye observer before the invention of the tele-

scope, deeply admired the Copernican system and recognized the genuine advance which it signified for astronomical thought. In particular he saw how radically planetary theory was simplified by having the planets revolve around the sun; their stations and retrogressions were correctly explained by the novel Copernican doctrine, and also the variation in their distances from the earth and in their apparent magnitude. But Brahe balked at accepting a moving earth—the very idea was repugnant to his metaphysical and religious preconceptions. And he was so thoroughly obsessed by the principle of plenitude that he regarded the vast gap between Saturn and the stars as a grave defect in Copernicus' world view. Hence, when he set about devising his own blueprint of the cosmos, he combined a stationary earth with heliocentric orbits for the planets.

Following the lead of Copernicus' first disciple, he somehow imagined that his own superb collection of observations justified the (perfectly sound) conclusion that Mars at opposition is nearer to the earth than is the sun; hence their orbits must intersect. And since they intersected, the orbits could not be material shells. Thus it was that Tycho Brahe, the confirmed plenitudinarian, delivered the knockout blow to the trembling principle. For, if the spherical shells were not real, there could no longer be any debate whether they were neatly joined or separated by interstices. They simply ceased to exist, save in the imagination for purposes of instruction. Tycho's proclamation of their death sentence is of such great importance to the history of ideas that it deserves quotation:

> The celestial mechanism is not a hard and impenetrable body filled with various real spheres, as has been generally believed heretofore, but it is a highly fluid and utterly simple substance. The planets revolve freely without being assisted or carried about by any real spheres. . . . In this arrangement of the heavenly bodies no absurdity follows from the fact that Mars at opposition comes nearer to the earth than does the sun. For this view admits no actual and incongruous interpenetration of the spheres (since they do not in fact exist in the heavens, but are set forth merely for the purpose of instruction and comprehension of the subject). Nor can the planetary bodies ever collide, or in any way disturb the harmonious motion which each of them pursues, however the imaginary spheres of Mercury, Venus and Mars may mingle with the sun's and cross through it.

The nonexistence of material spheres was confirmed by his discovery that the fiery comets rush freely about in cosmic space, beyond the moon amid the planetary orbits.

Tycho took a boundless pride in his unsound compromise between the stationary earth of Ptolemaic and Biblical tradition and the heliocentric planets of Copernicus. When Nicholas Reimers, surnamed Ursus (the bear), who was Imperial Mathematician to Rudolph II, Holy Roman Emperor, claimed priority in the invention of the Tychonic system, Brahe's wrath hounded the unhappy wretch to his grave and beyond. But Reimers made no provision for a closer approach of Mars to the earth than the sun's least distance. The tremendous implications of this fact, as first enunciated by Brahe, have already been set forth. And yet a reputable historian of astronomy declares, after due consideration, that this difference between the cosmologies of Brahe and Reimers is a negligible trifle!

If Copernicus struck the principle of plenitude in the solar plexus and Brahe delivered the knockout blow, it was Kepler who counted ten over the prostrate form. For when he discovered that the paths of the planets are ellipses and not circles or combinations of circles, he forever dissociated the heavenly bodies from unseen carrying spheres or spherical shells. The last hopes of the (reasonable) traditionalists perished when

the motion of the heavenly bodies was shown to be a product of the mutual attraction of their material masses and not of their ceaseless yearning for an unattainable perfection nor of the unperspiring exertions of Intelligences or Souls or Angels.

Yet the doctrine of the full universe, driven from the heavens, clung tenaciously to life on the earth. If a column of mercury rose in a barometer, nature was evidently filling an empty space, because it abhorred a vacuum. But somehow this distaste relaxed a little just before a storm, when the pressure of the atmosphere fell, and the same slackening occurred on the roofs of tall buildings and at the tops of mountains, where the air was less dense.

After the triumphant synthesis of terrestrial and celestial mechanics in Newton, the idea of fullness, divorced from the principle of continuity or contiguity, reappeared in modern astronomy in a new dress. The planets were known to be strung out at varying intervals in space, like beads on a celestial necklace. But when they were arranged in the order of their distance from the sun, was there not perhaps some underlying simple numerical relationship which could bind the several discrete bodies into a single, harmonious, organic whole? The most plausible suggestion of this sort—Titius,' or Bode's, law—called attention to the vast emptiness between Mars and Jupiter and led to the belief that a missing member of the series was still in hiding somewhere. When the accidental telescopic discovery of Uranus for the first time extended the chain of planets beyond those known to the ancients, it seemed to confirm Bode's law and provoked a systematic search to close the gap between Mars and Jupiter. At the opening of the nineteenth century there was found the first of the asteroids—that multitude of tiny bodies representing either the fragments of a disintegrated planet or the component parts of a planet that somehow failed to coalesce. Like Mendeleyev's Periodic Table of Chemical Elements, the arithmetical relationship pointed the way to the discovery of the unknown. In this quantified form, then, the principle of plenitude is applied to the solar system, and from time to time fresh attempts are made to remedy its imperfections and to learn whether it does indeed answer to some as yet dimly understood distribution of cosmic matter.

THE MARIANAS, CAROLINE, AND MARSHALL ISLANDS[1]

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BUREAU OF AGRICULTURAL ECONOMICS, U. S. DEPARTMENT OF AGRICULTURE

MANY Americans have wondered what Uncle Sam will do with the Mandated Islands taken from Japan during World War II. What can be done with the hundreds of Micronesian islands that are now under the military surveillance of the United States? The Marianas, Caroline, and Marshall Islands extend over 3,000 miles of the Pacific, yet the total land surface of 846 square miles is less than that of the state of Rhode Island. The 206 square miles of Guam, a possession of the United States since 1898, is in addition (see accompanying map).

The Marshalls are flat, sandy, coral islands, while many of the larger Caroline and Marianas islands are a combination of volcanic cores and coral reefs. The latter are comparatively rough but have small plateaus and coastal flats which are reasonably free from lava and coral obstructions. Most of the Mandates lie between 5° and 15° north latitude and accordingly have a tropical climate, with relatively heavy rainfall—particularly in the southern portions of the Marshalls and Carolines. The Marianas are characterized by a "dry season" from January to April, the severity varying considerably from year to year.

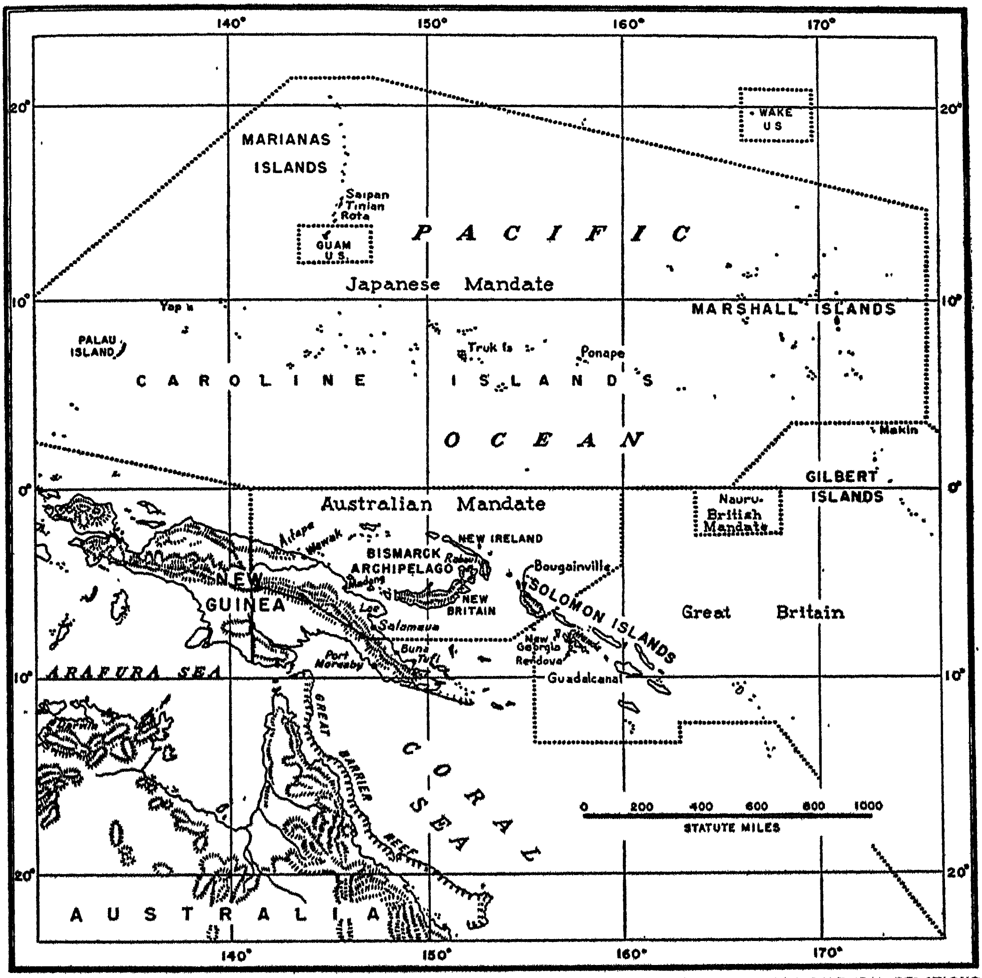
In 1937 the total civilian population of the Mandates was 112,267, of which 61,323 were Japanese colonists, 50,809 were natives, and 135 were of other origins. In addition, Guam possessed a population of 22,290 (1940), 90.5 percent of which were native Chamarros. The recent aboriginality of the natives, particularly the Carolinians and the Marshallese, and their crude living habits are of interest to most visitors to these islands. Many of the natives prefer to live from the roots and fruits of the land rather than exert sufficient effort to produce domestic foods. The culture of the Chamarros in the Marianas has been advanced considerably as a result of Catholic missionary influences introduced early in the seventeenth century by the Spanish. The resulting ideals and customs orient these people toward the West rather than the East.

The history of these islands has been varied and fascinating. The Spanish discovered the Marianas in the sixteenth century and by early in the seventeenth had established a limited administrative hold on all three groups. Until 1898 Spanish rule of the Marianas and the Carolines had been undisturbed. Guam was ceded to the United States during the course of the Spanish-American War (1898), and in the following year the remaining islands of the two groups were sold to Germany. Germany had exercised a protectorate over the Marshalls for a few years previously, and her claims were uncontested until 1914, when the Japanese began unofficially to organize the South Seas Government and to colonize the sparsely populated islands. In 1922 their claim was supported by the League of Nations mandate which provided authority over all three groups, with the exception of Guam in the Marianas.

There is a question now as to what the

[1] A fully documented article entitled "Resource Development in the Pacific Mandated Islands," by the same author, appeared in the *Journal of Land and Public Utility Economics*, August 1946.

[2] In addition to the references listed, this article is based on observations made by the author while on duty as Agricultural Officer, Naval Military Government, in the Pacific Ocean area. The author is solely responsible for all interpretations and conclusions made.



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THE MARIANAS, CAROLINE, AND MARSHALL ISLANDS

future holds for these distant microislets. Social scientists are proclaiming the need for reformation, the development of economies, the advancement of civilization. Our discussion poses some of the questions and problems which will be involved in any attempts to develop the resources of the Mandates. In the light of past development and the natural resources available, it should be possible to visualize some elements of the economic future for these native peoples, under the general assumption that the United States will continue to control the Mandates. However, questions of political policy will be avoided; likewise, the method of government and the bureaucratic problems involved are not a part of this discussion.

Natural Resources

The distant and scattered location of the Mandated Islands imposes a negative influence on the possibility for developing the relatively meager natural resources. The small, flat, coral islands of the Marshall group are relatively infertile, and the range of possible commercial productivity is very narrow. The coas-

tal flats and plateaus of the larger volcanic islands in the Carolines and Marianas offer some greater possibilities. The soils, consisting mainly of volcanic mud, coral residue, and varied organic content, are more fertile. In the best locations they are quite readily worked and provide a fair medium for vegetable and sugar-cane production. Plant growth is usually rapid, and some crops may be grown the year around, depending mainly on rainfall, insects, and disease.

The Spanish made little effort to develop the available land and marine resources. Shells and small amounts of copra were bartered from the natives. A naval base was established on Guam. Otherwise, the Spanish Pacific possessions were merely missionary outposts.

The Germans were more aggressive in some respects. They exerted considerable effort to develop both copra and the phosphate deposits. The United States made no attempt to develop or to secure trade with any of these islands, even though its Guamanian possession might have been a key trading post for the entire area. However, the Japanese were operating plantations and trading in copra in both United States and German territory prior to their first colonization in 1914. In that year they seized the German-developed phosphate mine on Angaur, West Carolines, and the railroads and other facilities in the Marianas. By 1922, when the mandate was effective, the South Seas Government was well under way toward developing the most favorable resources throughout the entire area.

The Japanese recognized that the islands were lacking in knowledge, essential skills, and cheap labor. Accordingly, they transferred these factors of production from Japan, Okinawa, and Korea by colonization. Moreover, the South Seas Government provided substantial subsidies to commercial enterprises in behalf of preferred types of production. Several agricultural experiment stations were established primarily for improving and developing sugar cane and cotton. Numerous fruits, vegetables, and shrubs were being acclimated and tested.

Land Utilization. The Japanese reported approximately 135,000 acres of cropland in the Mandates for 1937. Three qualifications are necessary, however. First, almost half of this acreage consisted of coconut and breadfruit lands, most of which is more or less unattended natural flora. Second, at least 60 percent of the sugar-cane lands in the Marianas is too steep to be tilled by means other than bulls and hand labor. These the Japanese used almost exclusively. Third, these estimates by the South Seas Government represent conditions existing before the war. Military installations since have been made on a substantial proportion of the land that was formerly the most suitable for agricultural uses. Derangement by grading, coral overlays, and other factors have greatly impaired these locations insofar as farming is concerned, even if all military uses were discontinued. With these qualifications in mind, the character of land use under the Japanese and the potential utilization pattern may be more clearly visualized.

Saipan, Tinian, and Rota Islands in the Marianas possess almost 82 percent of the 45,200 acres of *cultivated* cropland in the Mandates (excluding Guam), as reported for 1937. Sugar cane accounted for 76 percent of all cultivated land in the Marianas, and 62 percent of that for the entire Mandates. Fruits, vegetables, and minor fiber crops constituted the remainder. In addition, it was estimated that there existed 53,500 acres of undeveloped *arable* land, 85 percent of which is supposed to be in the Marianas. It is certain, however, that most of this acreage must be quite rough and usable only by hand processes. Lands which have not been developed consist of steep, rough, infertile ridge

tops that are subject to severe drought during eight months of the year.

In the light of these circumstances and after appropriate deductions for lands totally or partially destroyed by military activities, it is probable that not more than 10 percent of the lands farmed by the Japanese could be so used by methods similar to the commercial practices employed in the United States. Most of this acreage is in the Marianas.

In order to complete the picture for the three groups of islands, it may be worth while to note that the Guam Agricultural Experiment Station reported a total of 17,000 acres under "cultivation" in 1939. Actually, only 4,000 could be correctly described as cultivated, this acreage being devoted to corn, rice, sweet potatoes, tapioca, taro, and other fruits and vegetables. The remainder is coconut plantations. Breadfruit and coconut lands are often suitable for other uses if cleared. But the natives are strongly opposed to destroying any natural sources of food. They apparently never will forgive the Japanese for replacing the coconut with sugar cane.

The native Chamarros, Marshallese, and Kanakas, or Carolinians, do very little land cultivation if left to their own way of life. They prefer to depend heavily on the spontaneous native products which require a minimum of care and attention. Bananas, breadfruit, coconut, taro, sweet potatoes, yams, and other foods of perennial growing habits are a major source of their diet. Small patches of corn, squash, eggplant, and beans may sometimes be planted, but after planting they are often neglected. Even on Guam, where considerable effort has been exerted since 1909 in improving Chamarro farming, most of the native farms can scarcely be distinguished from the bush. However, the U. S. Military Government farm program on Saipan was reasonably effective under an association type of organization. Small 2-acre units were constantly supervised by native leaders, and various types of encouragement were provided.

Minerals. Japan valued the phosphate deposits of the Mandates very highly. Supplies of this fertilizer are needed in large quantities for home-island agriculture. Both rock and guano phosphates were mined in several locations, the principal developments being on Anguar, Fais, and Peleliu islands in the West Carolines, and on Rota and Saipan in the Marianas. More than 300,000 tons were taken from these locations in 1939.

The remaining deposits are estimated to be three to four million tons of high-grade rock and probably twice this amount of low-grade rock. The best rock is reported to vary from three to six feet in thickness.

In addition to phosphate, small deposits of aluminum, manganese, coal, lignite, and others are reported for various locations. Some have been worked on an exploratory basis; but it is unlikely that they have commercial development possibilities, except under special circumstances such as characterized the Japanese war efforts.

Fisheries. The entire Mandated area is well supplied with numerous types of fish. Japanese fishery operations in this area were centered in Palau, Truk, and Ponape in the Carolines, and at Saipan. Although the total catch obtained from these locations represented less than 1.5 percent of the Japanese Empire catch prior to the war, there is reason to believe that fishing may be an important aspect of the future economic development of the area.

In addition to commercial fishing, the natives normally depend on lagoon and reef fishing for numerous types of sea food. Fish are an important item of native diet since livestock are not produced in sufficient amounts for providing adequate meat supplies.

Shells, shark fins, sponges, and pearls form the basis for an important part of

the island handicraft production, and expansion of this industry may be feasible. The Japanese sponsored pearl and shell enterprises, especially in the Carolines, where these resources are most plentiful.

Sea-food processing consisted of drying, principally; two small canneries were operated in the southern portion of the area. All these facilities, including fishing boats, were destroyed during the war. Military Government units rehabilitated and added certain facilities in behalf of local food supplies for interned civilian populations.

Livestock. Japanese and native livestock production was limited to work stock and subsistence swine, poultry, cattle, and goats, with the exception of a few dairy cattle. Two small dairies on Saipan are known to have produced milk for sale in the towns of Garapan and Chalan Kanoa. But, according to Japanese records, less than 20,000 gallons of milk were produced annually in all three island groups. Most cattle were kept for draft and occasional slaughtering. Usually the consumption of beef and pork was limited to festive occasions, which are the very spice of native life.

Shortly before the war the Japanese initiated some hog projects in the northern Marianas. The aim was to provision troops stationed in the central Pacific. The hogs were fed from the native supply of copra available in these undeveloped small islands.

During the course of hostilities on the larger islands all livestock were released to roam at will. Military Government units have corralled sufficient numbers of cattle, poultry, and hogs to provide a source of breeding stock for the natives.

Industry. Sugar mills were the principal industries established by the South Seas Government interests. Three mills on Saipan and Tinian were capable of processing 34,000 tons of cane daily. Other mills were located on Rota; all were in the Marianas. Sugar, molasses, alcohol, and alcoholic beverages were processed in one or more locations.

Sustaining and subsistence industries were operated in several locations. For example, narrow-gauge railways, small cement plants, salt evaporators, charcoal ovens, handicraft shops, copra mills, and limited food-processing plants were operated at several points. Some exports from them were possible, but their primary function was to supply local needs.

Insofar as food production was concerned, copra and tapioca (cassava) starch took important positions, subordinate to sugar and fish only. The Marshalls and Carolines are reported to have processed more than 17,000 tons of copra for export in 1937. It is likely that this amount could be increased substantially by providing essential labor in the proper locations. Saipan, Palau, and Ponape produced an estimated total of 5,500 tons of tapioca starch in the same year. The cassava plant is a prolific producer of the starch-bearing tubers and may be grown on the rough coral lands that are not suited for certain other uses. Moreover, the production period is comparatively short. In terms of food supplies this crop may offer real possibilities where labor and processing facilities can be made available.

Small industries of this kind were, and probably will continue to be, important to the Japanese. Numerous subsidies were granted in behalf of every possible addition to food and raw material supplies. The *natives* have played little part in the enterprises of the South Seas Government, except as lands were leased from them. The more ambitious and talented were employed in various capacities.

Potential Development

War left the Japanese Mandated Islands in a state of destruction. Towns, mills, processing plants, and all other facilities were reduced to ruin. Sugar

cane, pineapples, bananas, papaya, coconut, and numerous other native food sources may readily be rejuvenated and expanded. Sufficient hogs, cattle, goats, and poultry have been corralled by Military Government units to form the basis for improved subsistence meat supplies.

In several locations Military Government agricultural programs have provided substantial facilities for rehabilitating subsistence agriculture. The United States Commercial Company has installed extensive facilities in several locations; in addition to the dairy and swine farms established on Guam, the U. S. Commercial Company has provided sizable vegetable and fruit production projects on Saipan, Tinian, Guam, Truk, and Peleliu. As the Japanese and Koreans were repatriated to their native lands, the U.S.C.C. also took over certain portions of Military Government farm projects in behalf of the subsistence of remaining natives. Some fishing and the handicraft industry projects previously established probably will continue to be basic functions of the meager native "economies."

In terms of commercial development of any type, however, the repatriation of the Japanese colonists removed essential labor supplies. Native labor almost certainly will remain more or less fully employed by the island military establishments and for island maintenance and service needs in most locations. This means that additional labor must be obtained from somewhere for any substantial resource development work.

United States Interests. It is not readily conceivable that the United States will have any strong interest in the limited resources of the Marshall, Caroline, and Marianas islands. Long distances, relatively high cost of production, and the interests of established producing areas are only three of the factors which are likely to limit United States interest in these islands to the military sphere. The administration of Guam as a naval base since 1898, with little attention to resource development, is sufficient precedent.

Of course there is a substantial responsibility for native welfare, which United States Military Government has made great efforts to improve. Hospitals, health services, employment at relatively high wages, expanded supplies of consumer goods, and numerous service functions have been provided. Schools, churches, and housing projects have already raised the native levels of living far above their means to maintain, unless continuous subsidies are provided.

The Agricultural Experiment Station which was maintained on Guam for 23 years was discontinued in 1932 because of lack of appropriations. Although considerable knowledge on island agriculture had been accumulated, this action was indicative of a lack of interest in natural resource development. The most important accomplishment, perhaps, with respect to creating trade with the Island of Guam, was the improvement in the quality of copra offered to the export market. However, island government, rather than agricultural interests per se apparently were responsible for this.

Copra probably is the only resource of these islands which United States trade interests may consider seriously. Since coconut production requires little attention (where the scale insect is not prevalent), copra may be produced with a small investment. Labor and drying facilities are all that are required. And it is possible that sufficient native labor could be made available for operating a worth-while copra trade, in a few locations at least.

Saipan, Tinian, and Rota, however, are practically void of coconut, and these three islands comprise the only substantial farm land acreages available for development. Hence, for the immediate future copra offers no opportunities in these locations. The chances are that the

natives may exert considerable pressure to have suitable farm lands assigned, at least to former landholders under the Japanese, for subsistence production. This may involve a redistribution of Saipan's present population of 4,200 Chamarros to Tinian and Rota. The latter islands were almost completely populated by Japanese colonists who have been repatriated to their native lands.

If United States trade in copra should be developed, there is reason to believe that small amounts of handicraft may become a supplementary item of trade. Limited quantities of raw materials and comparatively low quality workmanship, however, may limit handicraft to local trade with tourists and military personnel.

There is a strong possibility that commercial companies may be interested in developing the phosphate resources for supplying demands in the Philippines, Japan, or in China. The distances to the States put domestic markets out of range. But acute demands nearer by would undoubtedly take all that could be produced. Other minerals probably are not of sufficient importance to attract development by domestic interests.

So far, no provisions have been made for permitting access to resources of the islands for private development. Presumably, this would be possible after the final peace treaty has been consummated and within the bounds of military security. Operations of the United States Commercial Company gained access to land resources to aid the military efforts. Now that this program is in the process of liquidation, there will be no organized development of resources in the Japanese Mandates unless some new commercial or public effort is advanced.

There seems to be no good reason why the United States should subsidize any aspect of development other than that essential to security and reasonable levels of native welfare. Local employment of natives for military, island government, and service trade work, as already pointed out, is likely to absorb all native employables for some time to come. Private handicraft, farming, and other small native enterprises will undoubtedly give employment to some of those who prefer such work and to some who may not be able to adapt themselves otherwise. If copra and other supplementary trade is developed by private interests there is little doubt about the full employment of all natives. The development of a socioeconomic situation based on local trade and employment is more likely to insure a higher and more stable level of welfare than would be obtained by artificial economic relationships based on government subsidies, which are almost certain to be temporary.

Other Interests. It is impossible to appraise the possibility that various foreign interests may develop the limited resources of the Japanese Mandates because of the many unknown factors and relationships that may be involved. The extent that military security will allow resource development and the provisions by which resources might be made available are only two of the factors involved. These are outside the limits of this discussion.

However, the demands of nearby starving Asia for the smallest addition to food and raw materials supplies give impetus to the question of making available unused resources accessible for utilization. It is impossible to ignore the existence of Pacific island resources when the world is being searched for resources which will add to food supplies for needy areas. This applies not only to land, but to phosphate fertilizer, which is so generally needed by the areas which the United Nations are attempting to rehabilitate.

Problems of Development

The development of resources in the Marshalls, Carolines, and the Marianas

will involve numerous problems, irrespective of the character of the developing interest. The most apparent difficulty is the general lack of labor, unless unforeseen supplies come into the picture. The Chamarro population of less than 4,500 remaining on Saipan, Tinian, and Rota represents a very small labor force compared to the 39,000 Japanese civilians formerly on the three islands. Moreover, these islands represent the bulk of the available farm land.

Labor for phosphate development, fishing, and other enterprises is simply not available. More important, perhaps, is the lack of technical skill and knowledge. (Of course, the relatively few people required in this capacity could readily be imported.)

Insofar as agriculture is concerned, the problem of cultural practices is second only to that of labor supply. In the first place, laborsaving machinery cannot be used extensively. The rough and varied character of the land, the frequency of rainfall, and the rapid growth of weeds make large amounts of hand labor indispensable. Erosion is extremely rapid where land having the slightest slope is cultivated in "large" areas. The clean cultivation of papaya orchards on Saipan and Guam during the past few years gave emphasis to this fact. The native and Japanese methods of culture are not so conducive to erosion; they cultivate in small plots, with successive plot divisions planted to bananas, Napier grass, and other erosion-resisting plantings.

Although adequate saline-free water supplies have been developed by the armed services for occupational uses, supplies are not available for irrigation during the dry season. This limits the intensity of production. Some of the smaller islands, particularly those of coral origin, have no fresh water available to them.

In spite of DDT spraying, insects are severe handicaps to production. Among the more important insect pests are the European corn borer, corn earworm, aphids, leaf hoppers, and the coconut scale. The lack of seasonal climatic changes and the frequency of rainfall make control measures difficult. Almost continuous spraying is necessary for combating both sucking and chewing insects.

Plant diseases are no less troublesome, especially bacterial and fusarium wilts of tomatoes and downy mildew on beans and cucurbits. Resistant and acclimated varieties are needed. For example, the only varieties of cantaloupe available for subsistence gardens were thin-skinned and quickly susceptible to bacterial rot. Consequently, cantaloupe could not be allowed to ripen. Thick-skinned varieties would help to overcome this trouble.

Animal parasites and diseases are prevalent everywhere. Intestinal and stomach worms, pneumonia, liver and lung flukes, are serious menaces to poultry, hogs, and cattle. Goats seem to be comparatively free from these pests. The natives are nonetheless free from hookworm and other intestinal worms.

Another acute livestock production problem is the general lack of suitable pasture. Native cattle are constantly vulnerable to fluke infestations by reason of their dependence on swampy lowlands, especially during the dry seasons. The Japanese made no attempts to establish suitable pastures, depending mainly on wild vegetation and plant refuse for feed. With the establishment of a 75-cow dairy on Guam, the U. S. Commercial Company ran into this problem. It later attempted to provide some grazing by planting certain large stem grasses, the success of which has not been reported. It will be difficult to maintain upland pastures during the dry seasons, and lowland pastures are constantly subject to fluke infestation.

Most crops need moderate applications of fertilizer. The soils of the volcanic islands, if thoroughly weathered and

with a substantial organic content, will produce certain crops without fertilizer; but satisfactory yields of suitable quality require medium amounts of a complete fertilizer. Fertilizers used for vegetable production should be relatively low in nitrogen and high in potash and phosphorus. High nitrogen applications combined with the very rapid normal growth tend to produce excessive vines and foliage rather than fruit and roots.

A thorough understanding of, and an appreciation for, local conditions and requirements are essential to successful farming in these islands. Fortunately, the Guam Agricultural Experiment Station has placed on record, as annual reports from 1909 to 1932, a considerable amount of experimental knowledge that should be helpful in future farming endeavors. If this store of knowledge had been used as a guide to the food production programs during the past two years, much greater success might have been experienced. Certainly, the insistence on using highly bred varieties of seed corn from the United States, rather than a tried and proven "Guam Acclimated" variety would have been much more productive. The wasteful practice of applying 1,000 pounds of high-analysis (12–18–12) fertilizer per acre of corn and the importation of large quantities of useless heavy farm machinery might have been avoided. The provision of more than 60 farm tractors, during the war, to farm four or five hundred acres of land on Guam is an example. Such citations could be duplicated severalfold.

In conclusion, certain opportunities for resource development in the Marshalls, Carolines, and the Marianas appear more or less feasible. Copra and phosphate probably offer the most immediate possibilities. Even they may depend on the importation of labor, supplies, and satisfactory knowledge. The abandoned sugar cane, the major Japanese interest, is of little potential value, except that small portions may be rehabilitated to supply the natives with molasses and sugar. It is doubtful that the Japanese or Chinese will ever be given access to redevelop this source of sugar supply. Fishing in the surrounding waters certainly should be possible, if this area offers advantages, thus enhancing food supplies in this sector of the world.

There seems to be no reason why the United States should subsidize resource development beyond that necessary to fulfill our obligations to the natives. Even the feasibility of subsisting our military forces from the islands would be questionable. Continental interests, the demand for food of high quality, and the increasing adequacy of seagoing refrigeration make local dairying, hog farming, and vegetable production questionable ventures. The fact that nearly all necessary supplies can be imported at no greater expense than the cost of production on the islands is a good reason why local investments are likely to be comparative failures. Obviously, this is not to say that highly perishable fruits and vegetables should not be produced in family gardens. Nor is there any reason why native farmers should not be encouraged to produce fresh corn, native fruits, and vegetables of a quality suitable for supplementing imported food supplies.

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MATHEMATICAL ALLUSIONS IN POE

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It cannot well be denied that the prose works of Edgar Allan Poe impress the average reader as possessing a decidedly mathematical quality. In the first place, the remarkable precision of expression which was Poe's habitual style and in which, in fact, he took a conscious pride, suggests strongly, though quite irrelevantly, the austere and rigorous formulation of a mathematical argument. Second, the stories for which Poe is most widely known, *The Gold Bug, The Murders in the Rue Morgue, The Purloined Letter, and The Mystery of Marie Roget,* involve in an essential way, reasoning of a "Since . . . , therefore . . ." character strikingly reminiscent of the logical structure of the demonstrations of Euclid. Finally, to a degree far surpassing that of any other literary figure of comparable stature, Poe sprinkled his stories and his essays with specific references to mathematics and to mathematicians.

It is easy to understand why this combination of style, structure, and allusion should make Poe's writings seem to possess a mathematical flavor. Whether these features justify the inference often drawn and summed up in the words of Sir Arthur Eddington in a solicited letter to Arthur Hobson Quinn, quoted in the latter's book *Edgar Allan Poe*—"Poe, besides being fairly well informed in science and mathematics, seems to have had the mind of a mathematician . . ."—is another matter, however.

Many writers who by no stretch of the imagination could be termed mathematically inclined have written with great lucidity and precision. Likewise many a well-constructed detective story has been spun by authors to whom mathematics was nothing more than a vague recollection of dreary formulas and headaches. It thus seems clear that the real evidence bearing on Poe's familiarity with, and appreciation of, mathematical thought is to be found in his references, both direct and implicit, to mathematical topics; and this is the point of view we shall adopt here.

We shall not attempt to be exhaustive in our review of the mathematical allusions in Poe, for it is not our intention to compile a concordance of the technical terms to be found in his work. Our purpose is rather to discover the general nature of the mathematical references a great writer saw fit to employ, to observe their aptness as illustrations and their usefulness to him in creating effects, and to examine their significance as indications of his grasp of mathematical ideas. If some of our conclusions on the last point seem a bit severe we can console ourselves with the reflection that should our criticisms demonstrate that there is no reasonable basis for attributing any real mathematical insight to Poe, then his lapses from mathematical rectitude cannot properly be held against him. And in thus making conviction tantamount to acquittal, surely we do him no disservice.

Let us begin with some of the casual and more ornamental of the allusions, keeping in mind that as evidence bearing on our central question they are in general equivocal and of significance only if they are faulty, since almost all of them relate to quite elementary matters familiar, at least as names, to anyone who, in Poe's own words,

. . . possessed at one time . . . the average quantum of American collegiate lore—"a little Latin and less Greek," a smattering of physical and metaphysical science, and . . . a *very* little of the mathematics (Nathaniel Parker Willis in *The Literati of New York*).

Sometimes Poe refers to mathematical topics to epitomize complexity and obscurity. For instance, in *William Wilson* in the description of the old house he writes that

. . . the lateral branches were innumerable—inconceivable—and so returning in upon themselves that our most exact ideas in regard to the whole mansion were not very far different from those with which we pondered upon infinity.

And in a note in *Marginalia* he says:

Here is a plot which with all its complexity has no adaptation, no dependency:—it is involute and nothing more—having all the air of . . . the cycles and epicycles in Ptolemy's "Almagest."

And in *The American Drama* in discussing the typical critic,

He delights in mystery—revels in mystification . . . and talks about "stage business" and "stage effects" as if he were discussing the differential calculus.

That these quotations do not represent Poe's settled convictions is evident when they are contrasted with others of contradictory force. For example,

It is merely because a stepping stone here and there is needlessly left unsupplied in our road to differential calculus that this latter is not altogether as simple a thing as a sonnet by Mr. Solomon Seesaw (*Eureka*).

And in *The Rationale of Verse* we are told that

. . . the subject [versification] is exceedingly simple; one-tenth of it, possibly, may be called ethical; nine-tenths however appertains to mathematics, and the whole is included within the limits of the commonest common sense.

In extension of this idea Poe asserts in another place:

The highest order of the imaginative intellect is always preeminently mathematical, and the converse (*The Poets and Poetry of America*).

Frequently Poe's references are of a studied pseudoseriousness that is quite humorous. For instance, in describing the reaction of the citizens of Alexander-the-Great-onopolis to a newspaper article in which every *o* was replaced by an *x* because a rival printer had made off with all the *o*'s in the editor's font, Poe writes:

The more common conclusion, however, was that the affair was simply *X*-traordinary and in-*X*-plicable. Even the town mathematician confessed that he could make nothing of so dark a problem. *X*, everybody knew was an unknown quantity, but in this case (as he properly observed) there was an unknown quantity of *X* (*X-ing a Paragrab*).

Another in the same spirit occurs in *The Devil in the Belfry:*

Of the date of this origin [of the town of Vondervatteimittis] I grieve that I can only speak with that species of indefinite definiteness which mathematicians are at times forced to put up with in certain algebraic formulas. The date, I may thus say, in regard to the remoteness of its antiquity, cannot be less than any assignable quantity whatsoever.

And again in *Some Secrets of the Magazine Printing House:*

These publishers pay *something*—other publishers nothing at all. Here certainly is a difference—although to a mathematician it might be infinitesimally small.

A more factual example of this type appears in another note in *Marginalia:*

On the back of the book is a monogram . . . whose solution is a fertile source of trouble with all readers. This monogram is a triangular pyramid; and as in geometry the solidity of every polyhedral body may be computed by dividing the body into pyramids, the pyramid is thus considered as the base or essence of every polyhedron. The author, then . . . may mean to imply that his book is the basis of all solidity or wisdom—or perhaps since the polyhedron is not only a solid but a solid terminated by *plane faces*, that the "Doctor" is the very essence of all that spurious wisdom which will terminate in just nothing at all.

As a final example of this sort here is a quip that I confess I find quite amusing:

To speak algebraically: Mr. M. [Cornelius Mathews] is execrable but Mr. C. [William Ellery Channing] is $(x+1)$-ecrable (*James Russell Lowell*).

On occasion the allusions are quite apt figures of speech: "The mere succession of incidents, even the most spirited, will no more constitute a plot than a multiplication of zeros, even the most infinite, will result in the production of a unit" (*The American Drama*). However, it is likely that a person with any real feeling for mathematics would have substituted "addition" for "multiplication," since it should be clear that the multiplication of zeros involves no tendency toward unity, whereas the unlimited addition of zeros might well suggest to a naive mind an equally fallacious approach to magnitude. The latter rather than the former is thus the metaphorical equivalent of Mr. Willis' theory of plot construction.

In his essay *Cryptography* Poe discusses the ancient cryptographic device of the scytale, in which the message is written in the axial direction on a strip of parchment wound spirally on a cylinder, an exact duplicate of which is in the hands of the recipient of the message, and bases his scheme for finding the diameter of the cylinder and thus "breaking" the code upon the use of a cone around which at various stations the strip bearing the communication may tentatively be coiled. For in his words, "As in passing up the cone to its apex all possible diameters are passed over, there is no chance of failure." This shows some insight, perhaps, into the nature of continuity, but lest we here attribute too much credit to Poe, let us observe that the average teacher of advanced calculus usually has less difficulty making his students understand the proof of the theorem that "a function continuous over an interval takes on at least once within the interval every value between those which it assumes at the end points" than he does in convincing them that so obvious a result needs proof at all. Moreover, this property was known for a long time before Poe's day. In fact, he gives it all away himself in another of the fragments in *Marginalia:*

> This reasoning is about as convincing as would be that of a traveller who, going from Maryland to New York without entering Pennsylvania, should advance this feat as an argument against Leibnitz' Law of Continuity according to which nothing passes from one state to another without passing through all the intermediate states.

One cannot say with certainty whether this isolated note was intended as a serious comment on some argument Poe thought faulty, or whether it was jotted down as a pun on the word "state," though the latter is perhaps nearer the truth. In any event it reveals the probable source of Poe's knowledge of the theorem in question.

Of all his literary applications of mathematics, the one that seems to me most complimentary to Poe occurs in *Hans Pfaall* and again almost word for word in *The Balloon Hoax:*

> What mainly astonished me in the appearance of things below was the seeming concavity of the surface of the globe. I had thoughtlessly enough expected to see its real convexity become evident as I ascended; but a very little reflection sufficed to explain the discrepancy. A line dropped from my position perpendicularly to the earth would have formed the perpendicular of a right angled triangle of which the base would have extended from the right angle to the horizon, and the hypotenuse from the horizon to my position. But my height was little or nothing in comparison with my prospect. In other words the base and hypotenuse of the supposed triangle would have been so long when compared to the perpendicular that the two former might have been regarded as nearly parallel. In this manner the horizon of the aeronaut appears always to be upon a level with the car. But as the point immediately beneath him seems and is at a great distance below him, it seems also at a great distance below the horizon. Hence the impression of concavity; and this impression must remain until the elevation shall bear so great a proportion to the prospect that the apparent parallelism of the base and hypotenuse disappears.

This is well done and quite effective in maintaining the desired air of scientific accuracy in the development of the narrative. If it was original with Poe it

demonstrates that his limited training in geometry was surely not all lost.

Not all his references, however, can even with charity be appraised as favorably as the last pair. Further on in *Hans Pfaall* we find, for instance,

> The balloon had now . . . reached a height of *not less* certainly than 7254 miles above the surface of the sea. . . . At all events I undoubtedly beheld the whole of the earth's major diameter; the entire northern hemisphere lay beneath me like a chart orthographically projected, and the great circle of the equator itself formed the boundary line of my horizon.

This of course is false since from no finite distance can as much as half the surface of a sphere be surveyed. Later in the same story appears the assertion,

> The form of the moon's orbit being an ellipse of eccentricity amounting to no less than 0.05484 of the major semi axis of the ellipse itself, and the earth's center being situated in its focus. . . .

In this, although the decimal itself is correct, there is a fundamental misconception that cannot be argued away as mere hyperbole, the way any author but one hampered by a desire to pose as a mathematician might explain the previous quotation, for the eccentricity of an ellipse is not expressed as a fraction of the major axis of the figure at all. In fact, it is not a length of any description but a dimensionless combination of both the semimajor and semiminor axes, a and b, respectively, defined by the expression

$$\text{eccentricity} = \frac{\sqrt{a^2 - b^2}}{a}.$$

And in *The Purloined Letter*, at the end of a long passage on the limitations of mathematical thought to which we shall return in our discussion of Poe's attitude toward axioms, we are told:

> In short, I never yet encountered the mere mathematician who could be trusted out of equal roots, or who did not clandestinely hold it as a point of his faith that x^2+px was absolutely and unconditionally equal to q. Say to one of these gentlemen by way of experiment if you please that you believe occasions may occur where x^2+px is not altogether equal to q, and having made him understand what you mean, get out of his reach as speedily as convenient, for beyond doubt he will endeavour to knock you down.

Here, again is confusion. Of course "x^2+px is not altogether equal to q." In fact, it is almost never equal to q, being so for, at most, two values of x, and no mathematician or mathematical dilettante ever held the opposite view. What Poe did here in setting up his straw man was to project upon mathematicians his own uncertainty regarding the elementary distinction between an identity and an equation.

Poe frequently refers to Newton's *Principia*, but it is reasonable to question how much of it was in any sense intelligible to him in view of his misconception of so fundamental a matter as Newton's second law of motion. In several different places he makes the following statement. (We take the wording from *The Purloined Letter* again, for the lengthy passage from which we have quoted is sometimes cited as evidence of Poe's relative scientific maturity. *Cf.* Quinn, *loc. cit.*, 421.)

> The principle of the *vis inertia* for example seems to be identical in physics and metaphysics. It is not more true in the former that a large body is with more difficulty set in motion, and that its subsequent momentum is commensurate with this difficulty, than it is in the latter that intellects of vaster capacity . . . are yet the less readily moved.

If the figure of speech is good, it is at the expense of the mathematics and physics of the proposition for it is easy to show that the momentum of a body set in motion by a given force is not in general proportional to its mass. In particular, in the obvious special case in which the force is a constant independent of the mass, the momentum is likewise entirely independent of the mass, the greater resultant velocities of lighter bodies in such cases exactly compensating for what would otherwise be the defect in their momenta occasioned by their lesser masses.

An especially revealing passage is found in *Cryptography:*

In any of the ordinary books upon algebra will be found a very concise *formula* (we have not the necessary type for its insertion here) for ascertaining the number of arrangements in which m letters may be placed n at a time.

Poe could hardly have given himself away more completely, for the formula defining the number of permutations of m things taken n at a time is one of the simplest of all algebraic formulas to write and one of the few that do not require any special type. For instance, it might have been written in the notation preferred by the English-speaking mathematicians of Poe's day in the form

$$\frac{m(m-1)(m-2)\ \ldots\ 3.2.1}{(m-n)(m-n-1)\ \ldots\ 3.2.1}$$

or, had as little as one + sign been available,

$$m(m-1)(m-2)\ \ldots\ (m-n+1).$$

The still more compact forms preferred by the continental mathematicians,

$$\frac{m!}{(m-n)!} \quad \text{and} \quad \frac{\underline{|m}}{\underline{|m-n}},$$

which were perhaps the ones Poe had vaguely in mind, could likewise have been set up in type without employing any symbols not actually used later on in the essay itself. It is hard to shake off the conviction that Poe was bluffing and on a point involving elementary algebra but slightly removed from "the commonest common sense."

One field of mathematics with which Poe explicitly boasted some familiarity was probability, for in one of his letters to Mrs. Sarah Helen Whitman he wrote: ". . . to one accustomed as I am to the Calculus of Probabilities. . . ." His general attitude is represented by the following typical quotations:

Now this Calculus [probability] is in its essence, purely mathematical; and thus we have the anomaly of the most rigidly exact in science applied to the shadow and spirituality of the most intangible in speculation (*The Mystery of Marie Roget*).

The theory of chance . . . has this remarkable peculiarity, that its truth in general is in direct proportion with its fallacy in particular (*A Chapter of Suggestions*).

Coincidences in general are great stumbling blocks in the way of that class of thinkers who have been educated to know nothing of the theory of probabilities—that theory to which the most glorious objects of human research are indebted for the most glorious of illustrations (*Murders in the Rue Morgue*).

These all have an epigrammatic quality which it is difficult either to challenge or to accept. But there are other and more specific references that may be examined. At the conclusion of *Marie Roget* Poe cautions against assuming that the similarity between the facts in the mystery unraveled by Dupin and the facts surrounding the disappearance of the New York girl Marie Cecelia Rogers implies that the solutions of the two cases may be similar. In fact, he asserts that just because of the similarity of the data, dissimilarity of the denouements is to be expected. In his words,

. . . the very Calculus of Probabilities . . . forbids all idea of the extension of the parallel, —forbids it with a positiveness strong and decided just in proportion as this parallel has already been long drawn and exact. This is one of those anomalous propositions which seemingly appealing to thought altogether apart from the mathematical is yet one which only the mathematician can fully entertain. Nothing for example is more difficult than to convince the merely general reader that the fact of sixes having been thrown twice in succession by a player at dice is sufficient cause for betting the largest odds that sixes will not be thrown in the third attempt. A suggestion to this effect is usually rejected by the intellect at once. It does not appear that the two throws which have been completed and which now lie absolutely in the past can have any influence upon the throw which exists only in the future. The chance for throwing sixes seems to be precisely as it was at any ordinary time—that is to say, subject only to the influence of the various other throws which may be made by the dice. And this is a reflection which appears so exceedingly obvious that attempts to controvert it are received more frequently with a derisive smile than with anything like respectful attention. The error here involved . . . I cannot pretend to expose within the limits assigned to me at present; and with the philosophical it needs no exposure.

There is of course a twofold error here. In the first place, it is mathematically incorrect to advance the thesis that a long run of successes augurs strongly a failure on the next turn. To put it picturesquely, this is equivalent to personifying probability and endowing it with an intelligence (akin no doubt to that of Maxwell's demon doorkeeper, which is able to abrogate the second law of thermodynamics) so that it can "keep books" on the trend of the game and exert a continuous restoring influence toward the expected frequency of successes. Actually, there are only two logical ways to estimate what may happen on the next turn after a long succession of favorable trials. One is to do what Poe describes accurately but rejects, namely, to retain confidence in the original analysis, or assumption, of the probability and accept the inescapable conclusion that the chance of an additional success is exactly the same no matter what has happened on previous turns. The other is to revise the analysis in the light of the recent experimental evidence, in which case the chance of a further success is greater, not less, than it was.

The second error in the passage is a psychological one, namely, the assertion that most people are hard to convince that a failure is more than usually probable after a number of successes. Generation after generation of freshmen study the fundamentals of probability in college algebra, and the majority of those who make mistakes make just the mistake Poe did, an error so frequent that it has actually been given a name, the Gambler's Fallacy. Considering Poe's usually acute psychological insight, it is hard to understand how he came to make this second error, for surely human nature has not changed that much in one hundred years.

There remains one broad class of allusions that it is extremely interesting to explore. This contains Poe's numerous references to axioms, self-evidence, consistency, and related topics from the area which mathematics and logic share with one another. Here if anywhere a person with a mathematical mind, with or without extensive formal training, should have revealed that ability. But let us examine the record.

In places it seems that Poe was surprisingly modern. For instance, in the passage in *The Purloined Letter* from which we have already quoted, he makes Dupin say,

> The great error lies in supposing that even the truths of what is called *pure* algebra are abstract or general truths. . . . Mathematical axioms are not axioms of general truth.

And in *Eureka,* Poe's major excursion into cosmology, he writes,

> . . . as for self-evidence, there is no such thing. . . .

A little later he amplifies this assertion, declaring,

> Now it is clear not only that what is obvious to one mind may not be obvious to another, but that what is obvious to one mind at one epoch may be anything but obvious at another epoch to the same mind. It is clear moreover that what today is obvious even to the majority of mankind or to the majority of the best intellects of mankind may tomorrow be to either majority more or less obvious, or in no respect obvious at all. It is seen then that the axiomatic principle itself is susceptible of variation, and of course that axioms are susceptible of similar change. Being mutable, the truths which grow out of them are necessarily mutable, too. . . .

On the basis of quotations such as these, Dr. Paul Heyl in another solicited letter to Prof. Quinn credits Poe with an early and independent recognition of the fact, first made clear in the work of Bolyai and Lobatchewsky on hyperbolic non-Euclidean geometry, that the axioms of geometry are not self-evident truths.

Had Poe stopped with these rational and essentially modern observations it would be easy to let the compliment stand, but he did not. When it suited his purpose (as it frequently did) both before and after the above passages were written, axioms were still self-evident

truths. For example, in his essay on *Charles Dickens* he wrote (1842):

> Excellence may be considered an axiom, or a proposition which becomes self-evident just in proportion to the clearness or precision with which it is put. . . . It is not excellence if it need be demonstrated as such.

Later (1848) he repeated this thought almost word for word in *The Poetic Principle* and, with "beauty" substituted for "excellence," in *Critics and Criticism*. Even in *Eureka* he wavers:

> Now the laws of irradiation are *known*. They are part and parcel of the *sphere*. They belong to the class of *indisputable geometric properties*. [The italics are Poe's.] We say of them, "They are true, they are evident." To demand why they are true would be to demand *why* the axioms are true upon which their demonstration is based.

Before overlooking these contrary opinions and crediting Poe with nonetheless possessing the modern viewpoint, let us examine what inferences he drew from his occasional denials of self-evidence. The proper conclusion is that axioms being not necessarily self-evident or "inescapable" are therefore relatively arbitrary, that is, much more numerous than they otherwise would be, thereby making possible the coexistence of mutually incompatible but self-consistent doctrines. Poe reached no such conclusion. His denial of the traditional view was complete and utter and illogical. Because self-evidence could not validate an axiom, there were no axioms at all, demonstration was impossible, and truth rose out of intuition (the difference between which and individual or personal self-evidence Poe never made clear) in one blinding flash in which simultaneously premises and conclusions had their origin. Again and again in *Eureka* these ideas find expression:

> No such things as axioms ever existed or can possibly exist at all.
>
> Whatever the mathematicians may assert, there is in this world no such thing as demonstration.
>
> We have reached a point where only intuition can aid us.

To explain away this view by urging that Poe's real argument involved defining axioms as self-evident truths and then showing this class to be vacuous is hardly warranted in the light not only of some of the quotations we have already given, but also in the light of his wholehearted acceptance of the doctrine of John Stuart Mill that "ability or inability to conceive is in no case to be received as a criterion of axiomatic truth."

In both *Eureka* and in *Mellonta Tauta* Poe attacked Mill for his supposed violation of this principle in accepting the law of the excluded middle, and again in setting up a straw man revealed the confused state of his own ideas. He claimed that Mill accepted the principle of the excluded middle solely because he could not conceive of things being otherwise, which superficially does appear to contradict the "principle of conceivability." This shows clearly that Poe did not realize that axioms are axioms simply because someone declares they are and uses them in his subsequent discussion as such. The law of the excluded middle is in the modern sense an axiom of logic, and the fact that it appears self-evident and that most people cannot imagine it false neither proves it true nor yet renders it unacceptable as a postulate.

The lengthy passage in which Poe presents this attack on Mill should be studied by every embryonic debater. It is a brilliant example of a spurious but highly effective *reductio ad absurdum* of an opponent's position. Quinn and others regard it as a bizarre bit of humor inserted at the beginning of *Eureka*, perhaps in deference to the ageless tradition that every speech (*Eureka* was actually a lecture which Poe gave on various occasions) should begin with a witticism. However, it seems more reasonable to take it seriously and to suppose that Poe was aware of the forensic value of this attack on the methods of classical logic and, realizing further that his own remarks were obscure and

inconsistent in many places, that is, that they were at best prose-poetry and not science, chose this introduction to stifle logical objections by holding logic up to preliminary ridicule.

Since Poe entertained such uncertain ideas about axioms, it was only to be expected that his notions of the related matters of proof, truth, and consistency would be equally cloudy. We have already observed that he frequently denied the existence of rigorous demonstrations, yet he was quite willing to assert the absolute character of a mathematical proof if the occasion required it. Thus in *The Domain of Arnheim* he declares that "the mathematics afford no more absolute demonstrations than the sentiments of his art yield the artist." And in *Eureka* itself he goes so far as to compliment himself because his reasoning compares favorably with that of Euclid: "I maintain, secondly, that these conditions have been imposed upon me as necessities in a train of ratiocination *as rigorously logical as that which establishes any demonstration in Euclid.*" (The italics are Poe's.)

For Poe absolute truths exist with consistency as their warrant, for he says in *Eureka:* "A thing is consistent in the ratio of its truth—true in the ratio of its consistency. *A perfect consistency, I repeat, can be nothing but an absolute truth.*" (The italics again are Poe's.) Leaving aside the vexing and still unanswered question of how "perfect consistency" can be inferred, the idea that consistency or anything else can establish an absolute truth is strangely out of place among reputedly modern ideas.

Perhaps following Keats and the "truth-beauty, beauty-truth" philosophy of his *Ode on a Grecian Urn,* Poe likewise made beauty a basis for truth. After an extended description of the nebular hypothesis of Laplace, he declares (*Eureka*): "From whatever point we regard it we shall find it *beautifully* true. It is by far too beautiful, indeed *not* to possess Truth as its essentiality—and here I am profoundly serious in what I say."

A third and most remarkable basis for belief is complexity. Still discussing the nebular hypothesis, Poe says, "I may as well here observe that the force of conviction in cases such as this, will always with the right thinking be proportional to the amount of complexity intervening between the hypothesis and the result."

In quoting from *Eureka* as extensively as we have in the last paragraphs, we have not been unfair to Poe, for the arguments of the essay are the ones advanced by the protagonists of Poe, the scientific dreamer, as evidence of his prevision of modern astronomical theories, and Poe himself realized that it should be perfect and unassailable, for he wrote in a letter to Mrs. Jane Locke: "But for duties that just now *will not* be neglected or even postponed—the proof reading of a work of scientific detail [*Eureka*] in which a trivial error would involve me in very serious embarrassment—I would ere this have been in Lowell."

To probe deeper into the detailed arguments of *Eureka* would be an interesting but overwhelming task, and one to which the talents of a physicist or an astronomer were better suited than those of a mathematician. Moreover, the thing has been done to a degree by critics trying to decide whether or not the grandiose ideas of the origin of the universe contained in the essay indicate any weakening of Poe's admittedly unstable mind. My own feeling, shared I think by most critics, is that the minor confusions we have noted are representative of the state of the whole, and that if one reads it as scientific speculation it is impossible to escape the conviction that most of its quantitative statements are inaccurate and many of its descriptive passages highly ambiguous or mutually contradictory. Its essentially unscientific character may well be epitomized by apposing the following pair of quotations:

> *Each law of Nature is dependent at all points upon all other laws.*
>
> It is an admitted principle in Dynamics that every body on receiving an impulse or disposition to move will move onward in a straight line in the direction imparted by the impelling force until deflected or stopped by some other force. How then, it may be asked, is my first or external stratum of atoms to be understood as discontinuing their movement at the circumference of the imaginary glass sphere when no second force of more than an imaginary character appears to account for the discontinuance? I reply that the objection in this case actually does arise out of an "unwarranted assumption" on the part of the objector, the assumption of a principle in Dynamics at an epoch when no "principles" in anything exist.

Can it be science or the work of a mathematically inclined mind when that mind alone can say when laws are operative and when they are not, when forces act and when they do not, and when criticism is stifled by the arbitrary dictum that the physical principle advanced in support of an objection was not at that time valid, although half a dozen similar laws may have been invoked previously in the construction of the argument?

Eureka should not be judged by false standards, but read simply as a metaphysical prose-poem. And if we must relate it to similar ventures of the restless mind of man let us not read into it an anticipation of the expanding universe of the modern relativists, but let us simultaneously acknowledge Poe's scientific limitations and his known indebtedness to such German orientalists as Schelling, Fichte, and the two Schlegels and regard it more reasonably as his paraphrase of the central philosophy of the *Vedas*, the *Upanishads*, and the *Vedanta* of the Indians, as Prof. Forrest has pointed out in his book *Biblical Allusions in Poe.*

From the nature and frequency of his mistakes and misconceptions, both in *Eureka* where critics have for long been cognizant of them, and in his other essays where they have been less frequently remarked, it seems abundantly clear that Poe was not a poor mathematician but simply no mathematician at all. And of course there was no reason why he should have been. He took no mathematical courses during his brief stay at the University of Virginia, and while he did pursue mathematical studies at West Point it was only a few months before they terminated with his court-martial and dismissal. During his mature years when he had to labor unceasingly to gain the bare necessities of life it is doubtful that he had any time for study, although his familiarity with names and topics shows that he did a commendable amount of "browsing" in technical works.

As a person with respectable mathematical inclinations, rooted in a reasonable appreciation of the subject, Poe would naturally have ornamented his work with allusions from the field. As a nonmathematician his reason for such embellishment is more obscure, and has confounded some commentators into inferring ability on very superficial evidence. The real explanation probably lies deep in the processes of Poe's peculiar mind. A psychoanalytical theory of what might be called "Poe's legend of himself," well conceived and brilliantly written is to be found in the book *Edgar Allan Poe—A Study in Genius* by Joseph Wood Krutch. Although Poe's most recent, and perhaps most scholarly biographer, Quinn, rejects completely the Freudian approach of Krutch, it appeals to me as a reasonable analysis of Poe's personal and literary characteristics, and one which in particular is quite adequate to explain Poe's posturing with the most esoteric discipline of which he had any knowledge, mathematics.

BOOK REVIEWS

SCIENCE BOOKS FOR THE NONSCIENTIST

GOOD science makes good reading. Unfortunately, too many nonscientists—and some scientists—nurtured on stilted science textbooks, have not yet become acquainted with this mind-warming fact. The scientific classics molder on library shelves because the average reader, who voraciously devours biographies, does not know that many of the great scientific books are in large part warm and thrilling biographies of outstanding men of science. The lives of men like Newton, Darwin, Galileo, and the like are in their works.

In re-exploring scientific literature for its literary merit, I have turned up an incredible amount of material that is good reading as well as good science. Much of this material is to be found in an average library—but it does not circulate nearly as much as it should. There is a certain fear on the part of many nonscientists that they will neither understand nor enjoy scientific literature as written by its greatest masters. Once they get a real taste of it, however, they cannot get enough of it. The taste is easier to acquire than a liking for ripe olives or raw oysters.

The study of science as a cultural subject rather than a purely technical or mechanical one is growing and can be expected to continue growing. Many colleges are now introducing broad orientation courses in science for students who are not candidates for science degrees. Yale College, for example, is introducing such a course this year. The library can do a great deal to enrich the lives of many out-of-college individuals by acquainting them with books that make it possible to understand science as a way of life and thought and not merely a hobby.

To further the study of science as a cultural subject, I suggest that the following recommendations be made to librarians:

1. Do not segregate all the scientific classics among technical books. If the library has open "browsing" shelves, put some of the science books under "biography," "travel," and "essays." Descartes' "Discourse on Method," Benjamin Franklin's experiments on electricity, John Snow's "On Cholera," Langley's "Memoir on Mechanical Flight," and Faraday's diary are as much biography as they are science.

2. Keep and display science source books and anthologies. They will develop a taste for further reading. (And, incidentally, they make a wonderfully convenient shelf of reference books for the quick answer to many scientific questions.) The list of science source books given below should serve the needs of many libraries:

BAITSELL, GEORGE (editor). *Science in Progress* (1st, 2nd, 3rd, and 4th Series). New Haven: Yale University Press. 1945.

BEEBE, WILLIAM (editor). *The Book of Naturalists, An Anthology of the Best Natural History.* New York: Alfred A. Knopf. 1944.

CLENDENING, LOGAN (compiler). *Source Book of Medical History.* New York and London: Paul B. Hoeber, Inc. Harper & Brothers. 1942.

CULLIMORE, ALLAN R. (editor). *Through Engineering Eyes, Science Selections from Literature.* (Re-edited by Frank A. Grammer and James H. Pitman.) New York and Chicago: Pitman Publishing Corporation. 1941.

DAMPIER-WHETHAM, SIR W. C., and WHETHAM, MARGARET D. (arrangers). *Cambridge Readings in the Literature of Science.* New York: The Macmillan Company. 1924.

ELIOT, CHARLES W. (editor). *Harvard Classics, Vol. 38, Scientific Papers.* New York. 1897.

FULTON, JOHN F. (editor). *Selected Readings in the History of Physiology.* Springfield (Ill.): Charles C. Thomas. 1930.

KNICKERBOCKER, W. S. (editor). *Classics of Modern Science (Copernicus to Pasteur).* New York: Alfred A. Knopf. 1927.

LAW, FREDERICK HOUK (editor). *Science in Literature, A Collection of Literary Scientific Essays.* New York and London: Harper & Brothers. 1929.

LONG, E. R. (editor). *Selected Readings in Pathology from Hippocrates to Virchow.* Springfield: Charles C. Thomas. 1929.

MAGIE, WILLIAM FRANCIS (editor). *A Source Book in Physics.* New York and London: McGraw-Hill Book Company, Inc. 1935.

MAJOR, RALPH H. (editor). *Classic Descriptions of Disease.* Springfield: Charles C. Thomas. 1932.

MATHER, KIRTLEY F., and MASON, SHIRLEY L. (editors). *A Source Book in Geology.* New York and London: McGraw-Hill Book Company, Inc. 1939.

MOULTON, FOREST RAY, and SCHIFFERES, JUSTUS J. (editors). *The Autobiography of Science.* New York: Doubleday, Doran, Inc. 1945.

RATCLIFF, J. D. (editor). *Science Yearbooks,* 1943, 1944, 1945. New York: Doubleday, Doran and Company. 1943–45.

SHAPLEY, HARLOW, and HOWARTH, HELEN E. (editors). *A Source Book in Astronomy.* New York and London: McGraw-Hill Book Company, Inc. 1929.

———, RAPPORT, SAMUEL, and WRIGHT, HELEN (editors). *A Treasury of Science.* New York and London: Harper & Brothers. 1943.

SMITH, DAVID EUGENE (editor). *A Source Book in Mathematics.* New York and London: McGraw-Hill Book Company, Inc. 1929.

THOMS, HERBERT (editor). *Classical Contributions to Obstetrics and Gynecology.* Springfield: Charles C. Thomas. 1935.

WILLIUS, F. A., and KEYS, T. E. (editors). *Cardiac Classics.* St. Louis: C. V. Mosby Company. 1941.

3. Have simple exhibits of science books. Almost every year affords an "occasion" for the display of a book and a portrait of a great scientist. For example, 1943 was the four hundredth anniversary of the publication of Copernicus' famous *Revolution of the Heavenly Bodies* in the year of his death, 1543. 1945 was the hundredth anniversary of the birth of Wilhelm Konrad Roentgen and the fiftieth anniversary (on December 28) of his world-shaking announcement of the discovery of the X-ray. Excellent newsworthy exhibits would have been easy to construct on an "X-ray" theme. For the library that has fuller resources, the following display exhibit might well serve to call attention to its wealth of science-as-culture material:

The Ten Most Important Books in the History of Science

The underlying purpose of this exhibit is to reveal the correlation between the graphic arts—with special reference to printed *books*—and the development of scientific thought. Scientific development has gone forward through an interaction between observation and hypothesis, between things and thoughts, between instruments and ideas, between tools of experiment (e.g., microscope, telescope, electromagnet, air foil) and preservation of ideas in printed form. This exhibit places emphasis on those great ideas—such as the heliocentric universe and the origin of species—which were presented to, and preserved for, the world of scientific thinking in the form of *books*.

The lodestone of the exhibit should be the original editions, under glass, of the following books which were turning points in the history of science:

1. *De Revolutionibus Orbium Coelestium* (The Revolution of Heavenly Bodies). 1543. NICOLAUS COPERNICUS (1473–1543).
2. *De Humani Corporis Fabrica* (The Anatomy of the Human Body). (Seven volumes and an Epitome.) 1543. ANDREAS VESALIUS (1514–1564).
3. *Novum Organum* (The New Atlantis). 1620. FRANCIS BACON (Lord Verulam) (1561–1626).
4. *Exercitatio de Motu Cordis et Sanguinis* (Essay on the Motion of Heart and Blood). 1628. WILLIAM HARVEY (1578–1657).
5. *Discours de la Méthode* (Discourse on Method). 1637. RÉNÉ DESCARTES (1596–1650).

6. *Principia Mathematica Philosophiae Naturalis* (The Mathematical Principles of Natural Philosophy). 1687. SIR ISAAC NEWTON (1642–1727).
7. *Inquiry into the Cause and Effects of the Variolae Vaccinae.* 1798. EDWARD JENNER (1749–1823).
8. *An Essay on the Principle of Population.* 1798. THOMAS MALTHUS (1766–1834).
9. *On the Origin of Species by Means of Natural Selection.* 1859. CHARLES DARWIN (1809–1882).
10. (Visitor's Choice).

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NEW YORK, N. Y.

DESTROYED BY HIS FRIENDS

Luther Burbank, A Victim of Hero Worship. Walter L. Howard. 221 pp. Illus. $3.75. Chronica Botanica Co. Waltham, Mass. 1946.

WRITTEN by a leading horticulturist, this is the first book about Burbank that gives authentic information fairly and without prejudice. Much biographical material has been gathered from many sources. For the first time Burbank is placed in his proper background, making him a man rather than a legendary figure.

Any writer about Burbank and his work has the difficult task of sifting the exaggerated claims and misstatements arising both from Burbank's uncritical estimate of his work and the publications of writers who knew little or nothing about the scientific aspects of the subject. On the other hand, there is the overly-critical attitude of specialists in the seed and nursery trade and professional geneticists and biologists, who properly resent and distrust the nonsense about Burbank that has been too prevalent in the popular press. The background and setting of the conflicting interests that swirled about Burbank during the latter part of his life make the real accomplishments of a long life of hard work begin to stand out. The author states that he has endeavored to write a human interest story, and in this he has succeeded admirably.

Burbank is unique in that he is perhaps the only man who has tried to make a living out of plant breeding as an enterprise, separate from a seed and nursery business. Even he found this to be impossible, as in later years his income came more and more from the sale of standard varieties of seeds and plants. Without formal schooling beyond high school, Burbank became interested in this new field partly through contact with Professor Agassiz, of Harvard, who visited his father in their home at Lancaster, Mass., and partly through the writings of Darwin. A lucky find of a valuable potato seedling started him in the search for new kinds of plants that he was to pursue all his life.

The author points out that Burbank's chief difficulty was with the popular press and enthusiastic friends who made fairy stories out of his accomplishments. Burbank himself had an exaggeration coefficient of about ten and apparently made no attempt to hold within reason the imagination of writers even more gifted than he along this line.

When due allowance is made for all the extravagant statements and misinformation, there is real accomplishment, not in the science of genetics, but in the art of plant improvement. A list of Burbank products included in this book, condensed from *Bulletin 691* of the California Experiment Station by the same writer, is impressive. Horticulturists would like to see a comparison with other workers in the same field. Many specialists working with more restricted materials have accomplished more than Burbank, but no one has given this work more widespread publicity.

The author believes that professional biologists have been unjustly critical of Burbank because he was not an orthodox scientist who followed the rules for experimental procedure and publication in

scientific journals, and also that there is a certain amount of professional jealousy. The reviewer considers that any prejudice that may exist is due more to the unfair comparison that has been made with other workers in the same field who have accomplished more of lasting value than Burbank. Darwin, Mendel, and Galton were not professional investigators, but their place in the field of science is unquestioned. Although much that Burbank has done has a great deal of scientific interest and can be studied by students of heredity more than it has been, very little that he has accomplished has contributed anything to the better understanding of the laws of heredity and the principles of variation in living organisms that is fundamental to their improvement.

Every teacher and biologist interested in plant improvement will find this book a source of accurate information about one of America's most interesting and colorful figures, and it should help to correct an unfortunate attitude that has existed both on the part of the Burbank boosters as well as his detractors.

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BACTERIA OF THE OCEAN

Marine Microbiology. Claude E. ZoBell. xv + 239 pp. Chronica Botanica Co. Waltham, Mass.; G. E. Stechert and Co. New York. 1946.

THE TERM "marine microbiology," in the broadest sense, refers to all microscopic forms of life that are found in water. There have been many books concerning the protozoa and algae, but no volume especially concerned with marine bacteria, yeasts, and molds. The present volume seeks to remedy this gap, and, while it is a review primarily of bacteriological studies, the yeasts and molds also receive consideration.

Scattered over the globe are a few laboratories which specialize in the hydrobiology of inland waters and a still smaller number which are equipped for oceanic microbiology. The interests of the marine bacteriologist impinge on every phase of study which has been undertaken by the less specialized bacteriologist and include the distribution of microorganisms in water, floating plankton, and sediments; the physiology of these organisms; and their possible effect on marine ecology, industry, and public health. The curiosity of the bacteriologist concerning these studies has largely been left unsatisfied because no volume existed which organized the scientific output of the various laboratories.

Certainly none of the laboratories in the United States are unfamiliar to Dr. ZoBell, and, since there is scarcely a phase of marine bacteriology in which he has not had an active part, this versatility is reflected in the monograph. His own writings have dealt with the waters of the United States, from the steep slopes of the rising Pacific shore, through the heavy waters of Great Salt Lake and the fresh water inland lakes, to the drowned valleys of the Atlantic coast. To supplement this experience he has drawn upon the work of marine investigators in all parts of the globe. A single page of the monograph may contain references to the coastal waters of North America, the fresh or salt marshes of the Netherlands, the mud of the Dead Sea, or the Russian limans.

The inland bacteriologist approaching the field of oceanic microbiology should read attentively the chapter dealing with the difficulties of collecting samples from the sea. This should aid in the evaluation of results obtained from the studies of deep-water and bottom sediments, as well as in giving an understanding of the challenge of those vast areas as yet untouched by the sterile pipette. Since the monograph is written by a bacteriologist, some claims as

to the importance of bacteria advanced in this text will be disputed by the physical oceanographer, who is not apt to be greatly impressed by test tube experiments.

The book is of convenient size, well illustrated with comprehensible tables, and the sketches by Alma Broulik Carlin add to its interest and appearance.

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DAVID RITTENHOUSE

David Rittenhouse: Astronomer-Patriot. Edward Ford. 226 pp. $2.50. University of Pennsylvania Press. Philadelphia. 1946.

DAVID RITTENHOUSE was a truly great man. Edward Ford has proved it. And with facts only. No fiction, no glamor, no embellishment, no exaggeration, no fabrication. Just David Rittenhouse as he was. The book sustains one of my pet theories: in writing the history of a man or a nation, facts are more inviting than fiction; more impressive than fairy tales or detective stories; more thrilling than the wildest imaginations of the most modern historical novelist.

Ford has made his book interesting—at times thrilling—by telling, so appropriately, the story of Rittenhouse in words as simple, sentences as clear, and paragraphs as connected, as his life was simple, clear, and connected.

This farm boy was eight when he made a working model of a water-powered mill! He was twelve when an uncle died leaving him an English translation of the First Book of Newton's *Principia,* which changed the course of David's life away from farming (just as it had changed the course of all scientific thought throughout the world); and seventeen when he made the first Rittenhouse thirty-hour clock with works of wood! This famous clockmaker has now been dead a century and a half, yet forty of his clocks are still ticking on, still striking the hours of time. One of his famous clocks stands in the president's office of the University of Pennsylvania.

Rittenhouse was a master of many trades and occupations: a surveyor, engineer, teacher, librarian, clockmaker, translator, astronomer, politician, curator, and always a scholar and scientist. Public positions held by him included: city surveyor of Philadelphia, engineer of public works during the Revolution, trustee of the state's Loan Office, member of the Pennsylvania Assembly, State Treasurer, and the first director of the first mint in the United States.

In the field of science and philosophy, Rittenhouse held high and important honors and positions: librarian, curator, and, finally, President of the American Philosophical Society; fellow of the American Academy of Arts and Sciences, Boston; Professor of Astronomy and Vice-Provost, College of Philadelphia; fellow of the Royal Society of London; and trustee of the University of Pennsylvania. He was given the honorary degree of Master of Arts by the College of Philadelphia and by the College of New Jersey, the latter institution also granting him the degree of Doctor of Laws.

Among his constructions were an orrery (planetarium), a "metalic thermometer," an observatory, and numerous astronomical instruments.

Rittenhouse made an English translation of Gotthold Ephraim Lessing's play *Miss Sarah Sampson, or the Unhappy Heiress.* The translation was published by Charles Cist as *Miss Lucy Sampson, or the Unhappy Heiress,* and was attributed to "A Citizen of Philadelphia."

We are told by the author that in astronomy, mathematics, and physics Rittenhouse's grasp of fundamentals was complete, something which Benjamin Franklin could not and did not claim. Of this deficiency the latter was acutely aware, and so he could write to the lieutenant-governor of New York, Cadwal-

lader Colden, when Colden disputed his theory that ships must necessarily sail more slowly to westward than to eastward because of the rotation of the earth: "I ought to study the sciences I dabble in before I presume to set pen to paper." And so Franklin deferred to Rittenhouse's sounder knowledge in astronomy and mathematics. When he acquired a telescope equipped with a micrometer, he appealed to Rittenhouse for an explanation of the accessory. To men who valued astronomy and mathematical research and recognized the indispensability of scientific method, Rittenhouse, says Ford, had no peer in America. In his *Notes on Virginia* in 1781, Jefferson wrote:

> We have supposed Mr. Rittenhouse second to no astronomer living; that in genius he must be first, because he is self-taught. As an artist, he has exhibited as great proof of mechanical genius as the world has ever produced. He has not, indeed, made a world, but he has by imitation approached nearer its Maker than any man from the Creation to this day.

Jefferson, as other instances indicate, was given to the use of the most superlative language to describe the traits of those whom he liked and, in like manner, to attack those whom he did not like. As Ford points out, this and other encomiums quoted were, of course, too sweeping since in England, France, and Germany there were a number of astronomers and scientists who outranked Rittenhouse; but the fact still remained, as the author states, that in America Rittenhouse stood alone.

Rittenhouse dabbled in theories about the plurality of worlds and their possible inhabitants, as did Thomas Paine, and expressed the hope that if Mars and Venus were inhabited, they could not be reached by "British thunder, impelled by thirst of gain"! He lashed out at tyrants and was an aggressive Whig at all times. When Franklin withdrew from the Pennsylvania Assembly, Rittenhouse was chosen as his successor. Jefferson chided him for mixing in politics and neglecting science.

That Rittenhouse was a true liberal, devoted to the cause of democracy and common men, is conclusively established by the fact that he incurred the undying enmity of John Adams, who at heart was a monarchist, determined on having a king and an aristocracy in America. Adams let loose a tirade of adjectives against Rittenhouse: "a good, simple, ignorant, well-meaning, Franklinian democrat, totally ignorant of the world as an anchorite, an honest dupe of the French Revolution," etc. Ford says: Adams' "own revolutionary ardor had cooled since 1776." No, it had not cooled for it never existed. Adams, it is true, favored independence but not revolution. He was opposed to the transfer of the divine right of kings to the divine right of the people. He opposed democracy and favored a monarchy.

Rittenhouse was the "Mint-Builder" of our country. He purchased the ground for the first mint—the very first real estate ever owned by the United States—built the building and equipped it, and was the first director of the mint.

Rittenhouse joined no church. His mother was a Quaker, his father, a Mennonite. His first wife died, and he married again. Both his wives were Quakers, both were married "out of the meeting," and both were "disciplined" for their "indiscretions." Because of his belief in the plurality of worlds, in their probable inhabitation, and in Newtonianism, Rittenhouse was tagged an "atheist." In his address to the American Philosophical Society in 1775, he said:

> The doctrine of the plurality of worlds is inseparable from the religion. . . . Nothing can better demonstrate the immediate presence of the Deity in every part of space, whether vacant or occupied by matter, than astronomy does. It was from an astronomer St. Paul quoted that exalted expression, so often since

repeated, "In God we live, and move, and have our being!" . . . I would sooner give up my interest in a future state than be divested of humanity; I mean that good-will I have to the species, although one half of them are said to be fools and the other half knaves. Indeed I am firmly persuaded that we are not at the disposal of a Being who has the least tincture of ill—or requires any in us.

His aloofness toward the church, Ford suggests, was like that of many Colonial thinkers, who accepted tacitly the tenets of Deism, "a view strengthened by the fact that he found congenial the Unitarian views of Jefferson and Dr. Joseph Priestley."

The University of Pennsylvania Press is doing a much-needed work in presenting "Pennsylvania Lives" of men who contributed vitally to the revolutionary thought-structure of our way of living. Mr. Ford has done a splendid service in extending another great Pennsylvanian beyond the state and beyond the nation, to become a world influence. Only in the ideas of common people, whose hearts and minds live in the realm of things universal, and away from the narrowness of individualism and nationalism is there hope of individual, national, and world survival.

R. C. ROPER

NEW YORK, N. Y.

MATHEMATICS MADE EASY?

The Common Sense of the Exact Sciences. William Kingdon Clifford. Edited, with a preface, by Karl Pearson. Newly edited, with an introduction, by James R. Newman. Preface by Bertrand Russell. lxvi + 249 pp. Illus. $4.00. Alfred A. Knopf. New York. 1946.

WITH nearly all more or less educated people, even arithmetic is a "bookish" subject, let alone algebra or geometry. Before we have the time and the opportunity to learn about these matters from actual experience—by "common sense"—the school pounces upon us with its textbooks. Further learning becomes clothed in all the paraphernalia of the erudite, with all its forbidding symbolisms, its learned vocabulary, and all its—goodness-knows-by-whom—revealed truths and rules.

It is therefore very refreshing to find someone who reminds us that in spite of all these learned trappings the basic rules of arithmetic and algebra are nothing more and nothing else *but* "common sense"; especially if this is done in as simple and as convincing a manner as in the book under review.

The study of space begins with the assertion: "Geometry is a physical science." By now we have grown quite accustomed to this point of view. But in the eighties of the last century, when the "ideal world of geometry" was still excellent currency, this was a bold statement. Clifford develops the basic notions of geometry, using solids as his point of departure. He anticipated some of the ideas which later became popular owing to the writings of Henri Poincaré.

The author does not limit the scope of his discussion to the mathematical equipment that is the common possession of most readers. He tries to add to this store of knowledge and to widen the mathematical horizon of those who are willing to make the effort of following him in his entertaining presentation.

The book is printed in large type, with pleasing illustrations, and has a very attractive binding. It would be a fitting addition to any library and should be on the shelves of both our public and our school libraries.

It would seem, however, that a less ornate and much cheaper edition of this book would be desirable also, an edition that could readily find its way into the pocket of a high school student, into the rooms of a college dormitory, into the hands of those whose intellectual hunger is far ahead of their affluence.

N. A. COURT

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COMMENTS AND CRITICISMS

Coghlan and Gerard

The June issue of SM features two contributions so noteworthy that the writer feels constrained to comment briefly on them from the standpoint of a layman sympathetic to scientists at a time when scientific achievements and purposes are becoming the topic of conversation of most civilians.

First of all, allow me to congratulate you on that most timely article by Ralph Coghlan, "The Need for Science Writing in the Press." Anyone who has had the patience to wade through the various articles by philosophers, psychologists, and psychiatrists that have broken out in recent numbers of SM, purporting to speak for the great body of science about the controversial subjects of the day, must realize that such men have lost the power to express their ideas in the language of the common man whom they wish to reach. Indeed, the P–P–P division, if they really are qualified to act as mouthpieces for the inarticulate laboratory workers who are responsible for modern wizardry, must be hard put to it to understand one another's theories. Certainly, a convention of P–P–P's would be the last word in boredom to the average citizen, especially if international relations were discussed in terms of organic wholes and discrete integral processes of the hypotenuse.

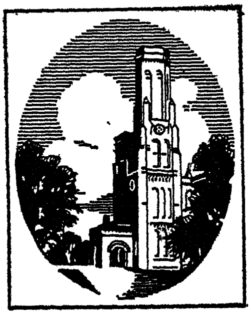
Of course, nobody expects a philosopher to employ the gracious phrases of a Robert Louis Stevenson, nor that he be endowed by nature with the incisive wit of a Will Rogers or a Mark Twain, nor that he stir men's souls with the marvelous oratory of a Winston Churchill. Yet the fact remains that many of our greatest men have dealt with their fellow humans in the language of the common man; so much so, indeed, that one is inclined to ascribe small stature to him who hides his thoughts behind a screen of equivocal verbiage. Mr. Coghlan has expressed the belief that many wise scientists are more than anxious to bring the implications of scientific research to the public in terms that the latter can understand. He might have mentioned the fact that Professor Harold C. Urey recently appeared as one of the speakers at a Town Meeting of the Air on the radio. That he answered the questions of the audience in language that all could comprehend and made some excellent points to elucidate the position of science in present world politics argues well for the ability of truly great scientists to come out from behind the screen and talk as the rest of us do.

Many years ago the writer had occasion to translate a number of technical articles from American scientific journals into Spanish for the newspapers of a certain South American country. How well he would have succeeded with some of the more recent contributions of American philosophers is, of course, quite debatable. These men now argue that life is so much more complex than it was that a new technique of expression is necessary to put over one's ideas. Be that as it may, it would seem that many seem to forget the fact of overspecialization, a process which entails coinage of trade terms such as those employed by psychoanalysts and others who wish to impress the ailing public and thus command higher fees. Since it now seems of such importance to let the rest of the world know what our scientists are thinking, and since the bulk of the information will suffer by translation at best, how unfortunate that they do not even speak the language of their own people.

The other article to which the writer refers is the masterful essay of Dr. R. W. Gerard on "The Biological Basis of Imagination." Here again one must be up on his toes to understand some of the terms employed. But Dr. Gerard goes to some pains to make the scientific verbiage comprehensible, and the effort to keep abreast of his reasoning is well repaid. Here is a man who must be a prodigious worker. We feel that he must be deeply interested in his work and that he has helped to push back the frontiers of that most interesting of all sciences, our knowledge of ourselves, our own innermost and personal selves. Your correspondent believes this is an inspired article, one in which Dr. Gerard expresses himself in elegant English approaching the lyric qualities of a poem. Such writing can come only from a man who is sure of his ground, one who has tested and retested his findings to a point that the pieces fit together into a whole, which, while still far from perfect, is sufficiently intelligible to give his readers something of the thrill which must be his as he goes ever deeper into this absorbing subject. Such an essay goes far toward re-establishing one's faith in the ultimate emergence of lasting truth through unremitting labor rather than through the empty theorizing that so many philosophical writers affect in lieu of honest effort. Congratulations, Dr. Gerard, and many thanks from at least one of your readers.—P. R. Gleason.

Correction: The writer of the letter on pp. 159–160, August SM, is Joshua L. Baily, Jr., San Diego, Calif.—Ed.

THE BROWNSTONE TOWER



August. "A day of torpor in the sullen heat of Summer's passion" wrote James Whitcomb Riley. Everyone should be taking his annual siesta by the old swimming hole or wherever waves lap on the beach or mountain streams murmur among the rocks. Why should anyone read the SM in August when he might read Riley or refuse to do more than contemplate the sky and sea and shadows? But Dr. H. M. Davis of Pennsylvania State College writes that his nonmember colleagues are wearing out his August issue. Why? Because Bruce S. Old in that issue poked a little mathematical fun at wartime committees, boards, and panels. It goes to show that if we must have an August issue it is well to put some levity in it. The times are so out of joint that a little satire should be acceptable in any issue. Thus we now present "The Last Canute" by Garrett Hardin, as an antidote to threatened "suffocation by our own intellectual excreta."

In lieu of a vacation the editor intends to keep on rambling through this page. It is really too hot to view with alarm or try to reform anything. S. 1850 died quietly last week in a committee of the House. Dr. Howard A. Meyerhoff, who did his best to prevent the abortion, performed the autopsy in *Science*. It seems that scientists went fishing or something when they should have been at the bedside. "Never mind," says the Navy, "we'll take care of fundamental research. "We'll not only protect the nation but build it up through research." This was the impression we obtained from Captain R. D. Conrad, Director of the Planning Division of the Navy's Office of Research and Inventions, the only Government agency now providing for the active and comprehensive support of fundamental research. The Captain and his men were cordial and enthusiastic. It was obvious that they have a Mission to perform, and there is no doubt that their program will advance science as well as the Navy. With the best naval and civilian advice they could obtain they have already approved and are supporting scores of research projects in colleges and universities throughout the country. Superconductivity, underwater sound, crystal strength, supersonic aerodynamics, propulsion, electronics, nuclear physics, mathematical computation, medicine, and psychology are some of the subjects of research discussed by Captain Conrad in a recent address on the Navy in research. We hope that some of these developments will be described in the SM, since most of the projects are free from security classification. The Navy's program of research is all to the good, for if war comes again, it will not be caused by increase in physical and biological knowledge but by social and moral ineptitude.

We like Captain Conrad and we wish him great success in his cooperation with civilian scientists. But our enthusiasm for his program is somewhat tempered by "the Mathematics of Committees, Boards, and Panels." To be sure, the Navy is not farming out projects conceived in a smoke-filled room, but it would be only human for some professors to shape their proposals for research to fit the supposed needs of the Navy as indicated by the titles of projects already under way. Thus the Navy may unintentionally restrict freedom of research. For this reason we hope that research men will never be entirely dependent for their bread and butter on appropriations from military or civilian Government agencies, or on grants from industry for that matter. The urge to make observations or experiments that would not appeal to any purse must not be completely repressed by Men of Measured Merriment.

In spite of the heat we seem to have forgotten our rambling vacation. "And Day sinks into slumber, cool and sweet, within the arms of Night."

F. L. CAMPBELL

THE SCIENTIFIC MONTHLY

OCTOBER 1946

RUNNING A PROFESSIONAL SOCIETY, OR THE HAPPY LIFE OF AN EXECUTIVE SECRETARY

By HENRY CLEPPER

SOCIETY OF AMERICAN FORESTERS, WASHINGTON

PROFESSIONAL societies in America have as many manifestations as a Hindu goddess.

They are numbered by the hundreds, and most professional workers belong to at least one. Casually ask a professional man why he is a member of his society, and he will probably murmur vaguely something about keeping abreast of developments in his field. Given more time to think about it, he may add that he belongs because it is the organization which represents his profession; that, while he doesn't get many direct benefits from it, on the whole it's a good thing; and, in short, he's been a member for years, likes to attend the meetings and read the journal when he's not too busy. He's often pretty busy.

Invariably, a description of a professional society in a directory or yearbook is written in cold and unemotional prose. Its stated objectives usually are "to advance scientific and educational development . . . to promote the technical practice . . . and to maintain high standards" of something or other, etc. Now these are necessary and desirable objectives in any endeavor, as every right-thinking person will agree. But in reading such a description, one would never suspect that the organization is composed of warm human beings who, for all their scientific training and specialized technical knowledge, enjoy drinking a cocktail, casting a fly rod, or relaxing with a "whodunit."

A certain United States senator, an unconscious and persistent bumbler, once remarked apropos the human side, "It is my observation, sir, that one individual has as much human nature as the next man—if not more so." Thus it is with professional societies and the hired help, the executive secretaries who run them. The human element is highly important.

Thoreau in one of his bitter moods (he was often bitter) complained, "Our life is frittered away by detail." I cannot think of any class of worker whose lives are more likely to be frittered away by detail than secretaries of professional societies—if they permit it. During a single day a secretary may be expected to display the sympathetic understanding of a father confessor, the diplomacy of an embassy attaché, the business acumen of a wholesale merchant, the salesmanship of a used-car dealer, the financial judgment of a stockbroker, and the information of a radio quiz expert. In between times he dictates letters, signs checks, reads manuscripts, writes

reports, talks to callers, keeps appointments, answers questions, gives advice, receives advice, laughs at funny and unfunny stories, shakes hands—and loves it. Often his really productive work may be done after office hours, usually at home.

Edward Gibbon once wrote that "whatsoever may be the fame of learning or genius, experience has shown me that the cheaper qualifications of politeness and good sense are more useful currency in the commerce of life." Assuming that a professional man has adequate scientific training and technical experience in his field, I would rate as his foremost qualifications for success as secretary of a professional society Gibbon's dictum regarding politeness and good sense. But I would add two others, sincerity and enthusiasm. And a sense of humor helps. Oh, how it helps!

Still another most important endowment for success—and happiness—as an executive secretary is a genuine liking for people. A story, doubtless apocryphal, is told of the late Clemenceau, Tiger of France. He is alleged to have said that he loved France but hated the French. If true, he would not have made a good executive secretary of a professional society. For a society is a body of persons, and an executive secretary must have the gregarious temperament that enjoys association with people.

Not only must he like people, he should be one of those fortunate individuals of whom it is always said with admiration, "Why, he can remember names as well as faces." Perhaps required experience for an executive secretary should be at least one year of employment as a room clerk in a large hotel. One is not born with an aptitude for remembering names and faces. It is learned the hard way.

Following a society meeting I spend many hours on trains cataloguing the members present and memorizing some salient characteristic of each so that I can, if lucky, identify him when next we meet. For example, I meet Brown for the first time in Maine. He smokes a curved-stem pipe, is working on the blister rust of white pine, and has an authentic New England accent. I file this information in my memory—the filing system, unfortunately, has many defects—and two years later our trails cross in Michigan. Something, as the saying goes, clicks. We shake hands, I call him by name, observe that he still fancies a curved stem whereas I adhere to a straight stem, ask about the blister rust project, and inquire about mutual friends in New England. Brown is charmed.

Don't misunderstand me. All this is not abracadabra merely to impress Brown. It has a more serious purpose. For he is a member of our society, his dues help pay the salaries of our staff, his membership along with thousands of others makes it possible to publish our professional journal. In short, I work for Brown. He doesn't think of me as his servant, but I do. But, alas, because there are several thousand Browns it is not possible to remember them all. One does one's best.

One more example. A prospective junior member writes for an appointment. Before he arrives I consult the yearbook of his school. I study his photograph, observe that he played varsity basketball, and was born in California. When he arrives we have subjects to start conversation, and he is humanly pleased that I am informed about him. In short, he is not merely a person; he is a personality.

I OFTEN wonder how many professional men and women who attend a meeting of their society realize the preparation that has gone into it. Even

after a program committee and a committee on local arrangements have been appointed, it is usually the executive secretary's responsibility to see to it that registration, printed programs, meeting rooms, banquet rooms, badges, tickets, secretarial help, press service, and all the other minutiae essential to the smooth functioning of a big meeting have been arranged.

A colleague, the executive secretary of an engineering society, once offered the suggestion that an essential qualification for his kind of job should be five years with Barnum and Bailey's circus. The analogy between a large professional meeting and a three-ring circus complete with side shows is not as far fetched as may appear.

Officers and members of professional societies like to maintain the polite fiction that no such thing as organization politics exists, as actually it does not in the opprobrious connotation of the term. But to deny that certain groups or individuals are not constantly active to promote special causes and policies, within the framework of the organization and through the use of the ballot, is unrealistic. Frequently, such causes are quite laudable, and the only obstacle to their acceptance is that a majority of the membership is opposed or indifferent. And here is where the executive secretary had better watch his step. If he fails to espouse the movement, he may be called a reactionary. If he goes all out for it, he may be dubbed radical. Even when he personally desires to do one or the other, he may do neither, not out of spinelessness, but simply in the interest of solidarity. Not to put too fine a point on it, the executive secretary is well advised to perform the function his title implies, that is, execute the policies of his officers and avoid championing causes and movements. If all this seems somewhat obscure to you, dear reader, *your* executive secretary will know what I mean.

To the extent that it is humanly possible, the executive secretary must be all things to all men. Like Ulysses, he must be a part of all that he has met.

Let's say he is invited to appear before a Congressional committee which is considering legislation of interest to his society. He must make his presentation in a confident manner which will artfully convey an impression of omnipotence combined with a subtle suggestion of respect for the profundity of the committee. If his statement is long he is wise to confine his oral presentation to ten minutes or less and request permission to include the longer version in the record. Such permission is rarely withheld. He will know every committee member by name, and if questioned his answers will be courteous, concise, and complete.

Your executive secretary must be ready on a moment's notice to respond to a toastmaster's request for a few remarks. To be truthful, I have never quite understood exactly what is meant by "a few remarks." But, like the preacher with a grace, a prayer, or a sermon always on tap, a secretary should have a repertoire of five-, ten-, fifteen-, twenty-, and thirty-minute "remarks" always available and suitable to the occasion. On the rounds of his appointed tasks he will as a matter of course attend numerous functions of which a luncheon or dinner is usually a part. I have been solemnly assured by a presiding officer as we entered a dinner meeting that there positively would be no speeches, only to have him rise an hour later, when everyone present was partly stupified with food, coffee, and cigars, and blandly call on me for "a few remarks." If Dante were writing today he would invent a special hell for such people. But I digress.

With his many miscellaneous and diverse activities as well as routine duties, one might assume that the executive secretary would have little time to keep up with current literature in his field and would be pardoned if he didn't. Not so. Even if his natural curiosity about new scientific developments and techniques is not sufficient to maintain his interest in professional journals and books, he had better have at least a speaking knowledge of "what's cookin'" in the major fields of specialization else the research and professorial elements in the society may tag him as "a nice chap but superficial." One may be damned with fainter praise than this, but few labels are harder to live down.

To summarize, the executive secretary of a professional society should possess the following native endowments and acquired abilities:

1. Adequate technical training in his field.
2. Tact, mature judgment, sincerity, and enthusiasm.
3. The temperament gregarious, combined with love of his fellow-men.
4. A sense of humor.
5. A conviction of the value of his profession to human progress.
6. Ability to remember names and faces, especially of dues-paying members in good standing.
7. Ability to represent his profession competently and favorably before the public.
8. Adroitness in avoiding extraneous issues and determination to stick to the main job.
9. A readiness to submerge his personality for the good of the cause.
10. A belief and pride in the nobility of service.

In short, Superman!

ATOMIC POWER

Before recorded history began
Prometheus, symbol of Science, brought us fire,
The altar and the hearth were our desire;
On these were built the faith and hope of man.
Then wood and stone and bronze and steel and steam
In turn became the servants of our will;
Knowledge we got and with it thought to fill

Each need and want, to realize each dream.
Again Prometheus brings a magic gift,
Which scarce we know if we should ban or bless.
The boldest hesitate, the fearful cower,
Before this weapon, deadly, sure and swift.
Amazed we stand, appalled at our success;
For who are we to wield this cosmic power?

THOMSON KING

THE MOTIONLESS ARROW

By N. A COURT

DEPARTMENT OF MATHEMATICS AND ASTRONOMY, UNIVERSITY OF OKLAHOMA

In the lore of mankind the arrow occupies a conspicuous place, a place of distinction. There is the heroic arrow with which the legendary William Tell, at the behest of a tyrant, shot an apple off his own son's head, to say nothing of the other arrow that Tell held in reserve for the tyrant himself, in case his first aim should prove too low. There is the soaring first arrow of Hiawatha that would not touch the ground before the tenth was up in the air. There is the universally famous romantic arrow with which Cupid pierces the hearts of his favorites—or shall I say victims?

There is also an arrow that is philosophical, or scientific, or, better still, both. This famous "motionless arrow," as it may best be called, has stirred the mind, excited the imagination, and sharpened the wits of profound thinkers and erudite scholars for well over two thousand years.

Zeno of Elea, who flourished in the fifth century B.C., confronted his fellow philosophers and anybody else who was willing to listen with the bold assertion that an arrow, the swiftest object known to his contemporaries, cannot move at all.

According to Aristotle, Zeno's argument for, or proof of, his embarrassing proposition ran as follows: "Everything, when in uniform state, is continually either at rest or in motion, and a body moving in space is continually in the Now [instant], hence the arrow in flight is at rest." Some six centuries later another Greek philosopher offered a somewhat clearer formulation of the argument: "That which moves can neither move in the place where it is, nor yet in the place where it is not." Therefore, motion is impossible.

The "motionless arrow" was not Zeno's only argument of its kind. He had others. Zeno had Achilles engage in a race with a tortoise and showed a priori that the "light-of-foot" Achilles could never overtake the proverbially slow turtle. In Aristotle's presentation, here is the argument: "In a race the faster cannot overtake the slower, for the pursuer must always first arrive at the point from which the one pursued has just departed, so that the slower is always a small distance ahead." A modern philosopher states the argument more explicitly: "Achilles must first reach the place from which the tortoise has started. By that time the tortoise will have got on a little way. Achilles must then traverse that, and still the tortoise will be ahead. He is always nearer, but he never makes up to it."

A third argument of Zeno's against motion is known as the "Dichotomy." In Aristotle's words: "A thing moving in space must arrive at the mid-point before it reaches the end-point." J. Burnet offers a more elaborate presentation of this argument:

> You cannot traverse an infinite number of points in a finite time. You must traverse half a given distance before you traverse the whole, and half of that again before you traverse it. This goes on ad infinitum, so that (if space is made up of points) there are an infinite number in any given space, and it cannot be traversed in a finite time.

Zeno had still other arguments of this kind. But I shall refrain from quoting them, for by now a goodly number of you have no doubt already begun to wonder what this is all about, what it is

supposed to mean, if anything, and how seriously it is to be taken. Your incredulity, your skepticism, reflect the intellectual climate in which you were brought up and in which you continue to live. But that climate has not always been the same. It has changed more than once since the days of Zeno.

To take a simple example. We teach our children in our schools that the earth is round, that it rotates about its axis, and also that it revolves around the sun. These ideas are an integral part of our intellectual equipment, and it seems to us impossible to get along without them, much less to doubt them. And yet when Copernicus, or Mikołaj Kopernik, as the Poles call him, published his epoch-making work barely four centuries ago, in 1543, the book was banned as sinful. Half a century later, in 1600, Giordano Bruno was burned at the stake in a public place in Rome for adhering to the Copernican theory and other heresies. Galileo, one of the founders of modern science, for professing the same theories, was in jail not much more than three centuries ago.

WHAT Zeno himself thought of his arguments, for what reason he advanced them, what purpose he wanted to achieve by them, cannot be told with any degree of certainty. The data concerning his life are scant and unreliable. None of his writings are extant. Like the title characters of some modern novels such as *Rebecca,* by Daphne du Maurier, or *Mr. Skeffington,* by Elizabeth Arnim Russell, Zeno is known only by what is told of him by others, chiefly his critics and detractors. The exact meaning of his arguments is not always certain.

Zeno may or may not have been misinterpreted. But he certainly has not been neglected. Some writers even paid him the highest possible compliment—they tried to imitate him. Thus the "Dichotomy" suggested to Giuseppe Biancani, of Bologna, in 1615 a "proof" that no two lines can have a common measure. For the common measure, before it could be applied to the whole line, must first be applied to half the line and so on. Thus the measure cannot be applied to either line, which proves that two lines are always incommensurable.

A fellow Greek, Sextus Empiricus, of the third century A.D., taking the "motionless arrow" for his model, argued that a man can never die, for if a man die, it must be either at a time when he is alive or when he is dead, etc.

It may be of interest to mention in this connection that the Chinese philosopher Hui Tzu argued that a motherless colt never had a mother. When it had a mother it was not motherless and at every other moment of its life it had no mother.

Some writers offered very elaborate interpretations of Zeno's arguments. These writers saw in the creator of these arguments a man of profound philosophical insight and a logician of the first magnitude. Such was the attitude of Immanuel Kant and, a century later, of the French mathematician Jules Tannery. To Aristotle, who was born about a century after Zeno, these arguments were just annoying sophisms whose hidden fallacy it was all the more necessary to expose in view of the plausible logical form in which they were clothed. Other writers displayed just as much zeal in showing that Zeno's arguments are irrefutable.

Aristotle's fundamental assumptions are that both time and space are continuous, that is, "always divisible into divisible parts." He further adds: "The continual bisection of a quantity is unlimited, so that the unlimited exists potentially, but it is never reached."

With regard to the "Arrow" he says:

> A thing is at rest when it is unchanged in the Now and still in another Now, itself as well as its parts remaining in the same status. . . . There is no motion, nor rest in the Now. . . . In

a time interval, on the contrary, it [a variable] cannot exist in the same state of rest, for otherwise it would follow that the thing in motion is at rest.

That it is impossible to traverse an unlimited number of half-distances (the "Dichotomy"), Aristotle refutes by pointing out that "time has unlimitedly many parts, in consequence of which there is no absurdity in the consideration that in an unlimited number of time intervals one passes over unlimited many spaces."

The argument Aristotle directs against "Achilles" is as follows:

If time is continuous, so is distance, for in half the time a thing passes over half the distance, and, in general, in the smaller time the smaller distance, for time and distance have the same divisions, and if one of the two is unlimited, so is the other. For that reason the argument of Zeno assumes an untruth, that one unlimited cannot travel over another unlimited along its own parts, or touch such an unlimited, in a finite time; for length as well as time and, in general, everything continuous, may be considered unlimited in a double sense, namely according to the [number of] divisions or according to the [distances between the] outermost ends.

Aristotle seems to insist that as the distances between Achilles and the tortoise keep on diminishing, the intervals of time necessary to cover these distances also diminish, and in the same proportion.

The reasonings of Aristotle cut no ice whatever with the French philosopher Pierre Bayle, who in 1696 published his *Dictionnaire Historique et Critique,* translated into English in 1710. Bayle goes into a detailed discussion of Zeno's arguments and is entirely on the side of Zeno. He categorically rejects the infinite divisibility of time.

Successive duration of things is composed of moments, properly so called, each of which is simple and indivisible, perfectly distinct from time past and future and contains no more than the present time. Those who deny this consequence must be given up to their stupidity, or their want of sincerity, or to the unsurmountable power of their prejudices.

Thus the "Arrow" will never budge.

The philosophical discussion of the divisibility or the nondivisibility of time and space continues through the centuries. As late as the close of the past century Zeno's arguments based on this ground were the topic of a very animated discussion in the philosophical journals of France.

A MATHEMATICAL approach to "Achilles" is due to Gregory St. Vincent, who in 1647 considered a segment AK on which he constructed an unlimited number of points B, C, D, . . . such that $AB/AK = BC/BK = CD/CK = \ldots = r$, where r is the ratio, say, of the speed of the tortoise to the speed of Achilles. He thus obtains the infinite geometric progression $AB + BC + CD + \ldots$, and, since this series is convergent, Achilles does overtake the elusive tortoise.

Descartes solved the "Achilles" by the use of the geometric progression $1/10 + 1/100 + 1/1000 + \ldots = 1/9$. Later writers quoted this device or rediscovered it time and again. But this solution of the problem raised brand-new questions.

St. Vincent overlooked the important fact that Achilles will fail to overtake the slow-moving tortoise after all, unless the variable sum of the geometric progression actually reaches its limit. Now: Does a variable reach its limit, or does it not? The question transcends, by far, the "Achilles." It was, for instance, hotly debated in connection with the then nascent differential and integral calculus. Newton believed that his variables reached their limits. Diderot, writing a century or so later in the famous *Encyclopédie,* is quite definite that a variable cannot do that, and so is De Morgan, in the *Penny Cyclopedia* in 1846. Carnot and Cauchy, like Newton, have no objections to variables reaching their limits.

The other question that arises in con-

nection with St. Vincent's progression is: How many terms does the progression have? The answer ordinarily given is that the number is infinite. This answer, however, may have two different meanings. We may mean to say that we can compute as many terms of this progression as we want and, no matter how many we have computed, we can still continue the process. Thus the number of terms of the progression is "potentially" infinite. On the other hand, we may imagine that all the terms have been calculated and are all there forming an infinite collection. That would make an "actual" infinite. Are there actually infinite collections in nature? Obviously, collections as large "as the stars of the heaven, and as the sand which is upon the seashore," are nevertheless finite collections.

From a quotation of Aristole already given it would seem that he did not believe in the actually infinite. Galileo, on the other hand, accepted the existence of actual infinity, although he saw clearly the difficulties involved. If the number of integers is not only potentially but actually infinite, then there are as many perfect squares as there are integers, since for every integer there is a perfect square and every perfect square has a square root. Galileo tried to console himself by saying that the difficulties are due to the fact that our finite mind cannot cope with the infinite. But De Morgan sees no point to this argument, for, even admitting the "finitude" of our mind, "it is not necessary to have a blue mind to conceive of a pair of blue eyes."

A younger contemporary of Galileo, the prominent English philosopher Thomas Hobbes (1588–1679), could not accept Galileo's actual infinity, on theological grounds. "Who thinks that the number of even integers is equal to the number of all integers is taking away eternity from the Creator." However, the very same theological reasons led a very illustrious younger contemporary of Hobbes, namely, Leibnitz, to the firm belief that actual infinities exist in nature *pour mieux marquer les perfections de son auteur*.

The actual infinite was erected into a body of doctrine by Georg Cantor (1845–1918) in his theory of transfinite numbers. The outstanding American historian of mathematics, Florian Cajori, considers that this doctrine of Cantor's provided a final and definite answer to Zeno's paradoxes and thus relegates them to the status of "problems of the past."

Tobias Danzig in his *Number, the Language of Science* is not quite so happy about it, in view of the fact that the whole theory of Cantor's is of doubtful solidity.

Whatever may have been the reasons that prompted Zeno to promulgate his paradoxes, he certainly must have been a man of courage if he dared to deny the existence of motion. We learn of motion and learn to appreciate it at a very, very early age; motion is firmly imbedded in our daily existence and becomes a basic element of our psychological make-up. It seems intolerable to us that we could be deprived of motion, even in a jest.

Nevertheless, the systematic study of motion is of fairly recent origin. The ancient world knew a good deal about Statics, as evidenced by the size and solidity of the structures that have survived to the present day. But they knew next to nothing about Dynamics, for the forms of motion with which they had any experience were of very narrow scope. Their machines were of the crudest and very limited in variety. Zeno's paradoxes of motion were for the Greek philosophers "purely academic" questions.

The astronomers were the first to make systematic observations of motion not due to muscular force and to make deductions from their observations. Man studied motion in the skies before he

busied himself with such studies on earth. How difficult it was for the ancients to dissociate motion from muscular effort is illustrated by the fact that Helios (the sun) was said by the Greeks to have a palace in the east whence he was drawn daily across the sky in a fiery chariot by four white horses to a palace in the west.

The famous experiments of Galileo with falling bodies are the beginning of modern Dynamics. The great voyages created a demand for reliable clocks, and the study of clock mechanisms and their motion engaged the attention of such outstanding scholars as Huygens. No small incentive for the study of motion was provided by the needs of the developing artillery. The gunners had to know the trajectories of their missiles. The theoretical studies of motion prompted by these and other technical developments were in need of a new mathematical tool to solve the newly arising problems, and calculus came into being.

The infinite, the infinitesimal, limits and other notions that were involved, perhaps crudely, in the discussion of Zeno's arguments were also involved in this new branch of mathematics. These notions were as hazy as they were essential. Both Newton and Leibnitz changed their views on these points during their lifetimes because of their own critical acumen as well as the searching criticism of their contemporaries. But neither of them ever entertained the idea of giving up their precious find, for the good and sufficient reason that this new and marvelous tool gave them the solution of some of the problems that had defied all the efforts of mathematicians of preceding generations. The succeeding century, the eighteenth, exploited to the utmost this new instrument in its application to the study of motion, and before the century was over it triumphantly presented to the learned world two monumental works: the *Mécanique Analytique* of Lagrange and the *Mécanique Céleste* of Laplace.

The development of Dynamics did not stop there. It kept pace with the phenomenal development of the experimental sciences in the nineteenth century. These theoretical studies on the one hand served as a basis for the creation of a technology that surpassed the wildest dreams of past generations and on the other hand changed radically our attitude toward many of the problems of the past; they created a new intellectual atmosphere, a new "intellectual climate."

Zeno's arguments, or paradoxes, if you prefer, deal with two questions which in the discussions of these paradoxes are very closely connected, not to say mixed up: What is motion, and how can motion be accounted for in a rational, intellectual way? By separating the two parts of the problem we may be able to come much closer to finding a satisfactory answer to the question, in accord with the present-day intellectual outlook.

The critical study of the foundations of mathematics during the nineteenth century made it abundantly clear that no science and, more generally, no intellectual discipline can define all the terms it uses without creating a vicious circle. To define a term means to reduce it to some more familiar component parts. Such a procedure obviously has a limit beyond which it cannot go. Most of us know what the color "red" is. We can discuss this color with each other; we can wonder how much the red color contributes to the beauty of a sunset; we can make use of this common knowledge of the red color for a common purpose, such as directing traffic. But we cannot undertake to explain what the red color is to a person born color blind.

In the science of Dynamics motion is such a term, such an "undefined" term, to use the technical expression for it. Dynamics does not propose to explain

what motion is to anyone who does not know that already. Motion is one of its starting points, one of its undefined, or primitive, terms. This is its answer to the question: What is motion?

You have heard many stories about Diogenes. He lived in a barrel. He threw away his drinking cup when he noticed a boy drinking out of the hollow of his hand. He told his visitor, Alexander the Great, that the only favor the mighty conqueror could possibly do him was to step aside so as not to obstruct the sun for the philosopher. Well, there is also the story that when Diogenes was told of Zeno's arguments about the impossibility of motion, he arose from the place where he was sitting on the ground alongside his barrel, took a few steps, and returned to his place at the barrel without saying a single word. This was the celebrated Cynic philosopher's "eloquent" way of saying that motion *is*. And did he not also say at the same time that motion is an "undefined term"?

St. Augustine (354–430) used an even more convincing method to emphasize the same point. He wrote:

> When the discourse [on motion] was concluded, a boy came running from the house to call for dinner. I then remarked that this boy compels us not only to *define* motion, but to see it before our very eyes. So let us go and pass from one place to another, for that is, if I am not mistaken, nothing else than motion.

The revered theologian seems to have known, from personal experience, that nothing is as likely to set a man in motion as a well-garnished table.

Let us now turn to the second part involved in Zeno's paradoxes, namely, how to account for motion in a rational way. All science may be said to be an attempt to give a rational account of events in nature, of the ways natural phenomena run their courses. The scientific theories are a rational description of nature that enables us to foresee and foretell the course of natural events. This characteristic of scientific theories affords us an intellectual satisfaction, on the one hand, and, on the other hand, shows us how to control nature for our benefit, to serve our needs and comforts. *Prévoir pour pouvoir,* to quote Henri Poincaré. A scientific theory, that is, a rational description of a sector of nature, is acceptable and accepted only as long as its previsions agree with the facts of observation. There can be no bad theory. If a theory is bad or goes bad, it is modified or it is thrown out completely.

"Achilles" is an attempt at a rational account of a race, a theoretical interpretation of a physical phenomenon. The terrible thing is that Zeno's theory predicts one result, while everybody in his senses knows quite well that exactly the contrary actually takes place. Aristotle in his time and day felt called upon to use all his vast intellectual powers to refute the paradox. Our present intellectual climate imposes no such obligation upon us. If saying that in order to overtake the tortoise Achilles must first arrive at the point from which the tortoise started, etc., leads to the conclusion that he will never overtake the creeping animal, we simply infer that Zeno's theory of a race does not serve the purpose for which it was created. We declare the scheme to be unworkable and proceed to evolve another theory which will render a more satisfactory account of the outcome of the race.

That, of course, is assuming that the theory of Zeno was offered in good faith. If it was not, then it is an idle plaything, very amusing, perhaps, very ingenious, if you like, but not worthy of any serious consideration. There are more worthwhile ways of spending one's time than in shadow boxing. Our indifferent attitude towards Zeno's paradoxes is perhaps best manifested by the fact that the article "Motion" in the *Britannica* does not mention Zeno, whereas Einstein is

given considerable attention; the *Americana* dismisses "Motion" with the curt reference "see Mechanics."

Consider an elastic ball which rebounds from the ground to $\frac{2}{3}$ of the height from which it fell. When dropped from a height of 30 feet, how far will the ball have traveled by the time it stops? Any bright freshman will immediately raise the question whether that ball will ever stop. On the other hand, that same freshman knows full well that after a while the ball will quietly lie on the ground. Will we be very much worried by this contradiction? Not at all. We will simply draw the conclusion that the law of rebounding of the ball, as described, is faulty.

The difficulties encountered in connection with the question of a variable reaching or not reaching a limit are of the same kind and nature. The mode of variation of a variable is either a description of a natural event or a creation of our imagination, without any physical connotation. In the latter case, the law of variation of the variable is prescribed by our fancy, and the variable is completely at our mercy. We can make it reach the limit or keep it from doing so, as we may see fit. In the former case it is the physical phenomenon that decides the question for us.

Two bicycle riders, 60 miles apart, start towards each other, at the rate of 10 miles per hour. At the moment when they start a fly takes off from the rim of the wheel of one rider and flies directly towards the second rider at the rate of 15 miles per hour. As soon as the fly reaches the second rider it turns around and flies towards the first, etc. What is the sum of the distances of the oscillations of the fly? In Zeno's presentation the number of these oscillations is infinite. But the flying time was exactly 3 hours, and the fly covered a distance of 45 miles. The variable sum actually reached its limit.

The sequence of numbers 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, . . . obviously has for its limit zero. Does the sequence reach its limit? Let us interpret this sequence, somewhat facetiously, in the following manner. A rabbit hiding in a hollow log noticed a dog standing at the end near him. The rabbit got scared and with one leap was at the other end; but there was another dog. The rabbit got twice as scared, and in half the time he was back at the first end; but there was the first dog, so the rabbit got twice as scared again, etc. If this sequence reaches its limit, the rabbit will end up by being at both ends at the same time.

If a point Q of a curve (C) moves towards a fixed point P of the curve, the line PQ revolves about P. If Q approaches P as a limit, the line PQ obviously approaches as a limiting position the tangent to the curve (C) at the point P; and if the point Q reaches the position P or, what is the same thing, coincides with P, the line PQ will coincide with the tangent to (C) at P.

If s represents the distance traveled by a moving point in the time t, does the ratio s/t approach a limit when t approaches zero as a limit? In other words, does a moving object have an instantaneous velocity at a point of its course, or its trajectory? Aristotle could not answer that question; he probably could not make any sense of the question. Aristotle agreed with Zeno that there can be no motion in the Now (moment). But to us the answer to this question is not subject to any doubt whatever: we are too accustomed to read the instantaneous velocities on the speedometers of our cars.

The divisibility or the nondivisibility of time and space was a vital question to the Greek philosophers, and they had no criterion according to which they could settle the dispute. To us time and space are constructs that we use to account for physical phenomena, con-

structs of our own making, and as such we are free to use them in any manner we see fit. Albert Einstein did not hesitate to mix the two up and make of them a space-time continuum when he found that such a construct is better adapted to account for physical phenomena according to his theory of relativity.

I HAVE dealt with the two parts of Zeno's paradoxes: the definition of motion and the description of motion. There is, however, a third element in these paradoxes, and it is this third element that is probably more responsible for the interest that these paradoxes held throughout the centuries than those I have considered already. This is the logical element.

That Zeno was defending an indefensible cause was clear to all those who tried to refute him. But how is it possible to defend a false cause with apparently sound logic? This is a very serious challenge. If sound logic is not an absolute guaranty that the propositions defended by that method are valid, all our intellectual endeavors are built on quicksand, our courts of justice are meaningless pantomime, etc.

Aristotle considered that the fundamental difficulty involved in Zeno's argument against motion was the meaning Zeno attached to his "Now." If the "Now," the moment, as we would say, does not represent any length of time but only the durationless boundary between two adjacent intervals of time, as a point without length is the common boundary of two adjacent segments of a line, then in such a moment there can be no motion; the arrow is motionless. Aristotle tried to refute Zeno's denial of motion by pointing out that it is wrong to say that time is made up of durationless moments. But Aristotle was not very convincing, judging by the vitality of Zeno's arguments.

Our modern knowledge of motion provides us with better ways of meeting Zeno's paradoxes. We can grant Zeno both the durationless "Now" and the immobility of the object in the "Now" and still contend that these two premises do not imply the immobility of the arrow. While the arrow does not move in the "Now," it conserves its capacity, its potentiality of motion. In our modern terminology, in the "Now" the arrow has an instantaneous velocity. This notion of instantaneous velocity is commonplace with us; we read it "with our own eyes" on our speedometers every day. But it was completely foreign to the ancients. Thus Zeno's reasoning was faulty because he did not know enough about the subject he was reasoning about.

Zeno's apparently unextinguishable paradoxes, as they are referred to by E. T. Bell in an article recently published in *Scripta Mathematica*, will not be put out of circulation by my remarks about them. I have no illusions about that; neither do I have any such ambitions. These paradoxes have amused and excited countless generations, and they should continue to do so. Why not?

SOPHIE GERMAIN

By JESSE A. FERNÁNDEZ MARTÍNEZ

If a thin circular sheet of metal be fastened firmly at the center by a clamp and if a violin bow be drawn across its edge, a musical note will be produced. The plate is thrown into vibration by the bow; the vibration does not all come up at once or all go down at once, but divides itself into some even number of sectors, say, six or eight, and as one sector goes up the sector on each side of it goes down. The line between two adjacent sectors goes neither up nor down but remains at rest. If sand be scattered evenly over the plate before the musical note is produced, it will be shaken off the parts which are most in motion and it will collect in the lines of rest, or "nodal lines," as they are called. Different musical notes cause the plate to be differently divided up, and the state of vibration of the plate is made plain to the eye by the lines of sand marked out on it. This experiment, a very striking one at that time, was performed at Paris soon after its discovery by Chladni in 1808. It created a great sensation, and a commission was appointed to repeat it with various modifications and to make a report upon it. The Institute of France, at the suggestion of Napoleon, offered its Grand Prix for a mathematical discussion of the phenomenon. Great mathematicians were not lacking in Paris at the time—Lagrange, Laplace, Legendre, Poisson, Fourier—but none of them was inclined to undertake this problem; Lagrange, in fact, had said that it could not be solved by any of the then known mathematical methods. The offer was twice renewed by the Institute, and in 1816 the prize was conferred upon a woman, Mlle Sophie Germain.

It is very remarkable that so great a distinction as to have received the prize of the Institute of France for a profound mathematical discussion should not have preserved the name of Sophie Germain from oblivion, but it has not done so. There are probably not a score of persons in this country who have ever heard of her, and in her own country she is not usually mentioned among its famous women. As proof that women may be pure mathematicians, Mrs. Somerville, outside of Italy and Russia, has had to stand alone. This is unfortunate, for the detractors of her sex have maintained that her work, though exceedingly profound, was not remarkable for originality. That charge cannot be brought against Sophie Germain. She showed great boldness in attacking a physical question which was at that time entirely outside the range of mathematical treatment and the more complicated cases of which had not been submitted to analysis at the time. The equation of elastic lamina, which is still called Germain's equation, formed the starting point of a new branch of the theory of elasticity. In her later years Sophie Germain turned her attention to questions of philosophy, and a high German authority discovered that her philosophical writings contain the germ of the Positive Philosophy of Comte. It is a curious thing that a woman so deserving of recognition has not received it in a fuller measure; it must be looked upon as one of those accidents by which the distribution of praise for merit is too often badly regulated. A mathematician, so remote is his subject from the ordinary concerns of men, has to be a very great mathematician indeed to be so much as heard of by the general public. Sophie Germain, besides deserving remembrance on account of her contributions to science, had

a charming personality, and the few details that have been preserved concerning her life are not without interest. The authority for them is an article by Libri, the Italian mathematician, which appeared in the *Journal des Débats* at the time of her death. Later writers, including the author of the biography prefixed to the new edition of her philosophical works, which was published in 1879 (Paris: P. Ritti), have added little that is important to his account.

On April 1, 1776, in a modest house in the Rue Saint Denis in Paris, Marie Sophie Germain was born. Her parents were Ambroise François Germain and Marie Madeleine Gruguelu. Not much can be told about her family. It is known only that her father, a skillful goldsmith, belonged to the cultivated and liberal *bourgeoisie,* and that he was the partizan, if not the friend, of the philosophers and the political economists. It is plain that she must have passed her earliest years in a family in which there were plenty of serious subjects for conversation. She soon exhibited great maturity of intellect and remarkable depth of feeling. Her gloomy anticipations concerning the future of her country were a distinct cause of suffering to her, and she sought for some occupation sufficiently absorbing to distract her attention from her fears. At the age of thirteen she was one day turning over the pages of Montucla's *History of Mathematics* in her father's library when she came upon the eloquent account of the death of Archimedes—how he was so absorbed in the consideration of a geometrical figure that he heard nothing of the taking of Syracuse, or of the plundering of the city, and that, when a Roman soldier appeared before him, he met death at his hands without raising his eyes from his work. She conceived a sudden passion for a science that could induce such absolute concentration and such total oblivion from the cares and griefs of life and she resolved at that moment to devote herself to the study of mathematics. That resolution she carried out. She had no teachers, she had few books, but she had an unlimited store of energy. She studied day and night. Her family were alarmed at so much ardor and endeavored to turn her attention to more ladylike pursuits. They tried the plan of putting out her fire and taking away her clothes at night, but she was found in the morning wrapped up in blankets, absorbed in her studies in a room so cold that the ink was frozen in the inkstand. It is a curious coincidence that at that very same time, Mrs. Somerville, in her little village in Scotland, was obliged to wrap herself up in blankets to pursue her studies before breakfast, because her whole day had to be devoted to the practice of music and painting and to her lessons at the shop of the pastry cook. Before a strength of will so remarkable at her age Sophie Germain's family at last yielded, and she was allowed to dispose of her time and her talents as she pleased.

But no matter what the energy brought to bear upon them, the higher mathematics present a long and toilsome course of study to anyone who wishes to master them. Sophie Germain carried on this laborious work with constantly increasing satisfaction. Toward the end of her life she still spoke with animation of the happiness she experienced when she first found herself in a position to take up the Differential Calculus of Cousin. But soon a new difficulty presented itself. It was absolutely necessary to her further progress that she should read certain works which were in Latin, and she did not understand that language. Unaided and alone, she learned it and in a short time she was able to read the works of Euler and Newton. Her ambition at this time took a

wider range, and, carried away by the philosophical spirit which held sway in the great *Encyclopédie,* she extended her reading over the entire field of the sciences and laid the foundations for that work which, forty years later, was to secure her a place among the founders of the Positive Philosophy.

In 1794 the École Polytechnique was founded. Legrange, Prony, Fourcroy, and Monge were among its lecturers. Sophie Germain was then eighteen years of age. Anxious to profit by so valuable a means of instruction, she procured for herself students' notebooks, especially of the courses in the chemistry of Fourcroy and in the analysis of Lagrange. She did more. The students were in the habit of handing in to the professors at the end of a course their observations on the lectures they had attended. Under the supposed name of a student, Le Blanc, she sent her notebooks to Lagrange. He noticed them, publicly praised them, found out their real author, and, having made her acquaintance, became the friend and counselor of the young mathematician. The circumstances under which she was discovered, the approbation of the illustrious author of the *Mécanique Analytique,* her youth, some details concerning her studies—all this excited attention and procured for her sympathetic friends. Soon she had established relations, either directly or by correspondence, with all the learned men of the period. Everyone was solicitous of the honor of being presented to her, learned works were dedicated to her, and her house became a center for the brilliant conversation of the most distinguished men of the day.

Some years later, Gauss's great work on the *Theory of Numbers* appeared. Mlle Germain at once turned her attention to this subject. She made numerous researches in it and, under the pseudonym of Le Blanc, she sent her notes to the celebrated professor of Göttingen, persuaded, she wrote, that he would not "disdain to enlighten with his advice an enthusiastic amateur of that science which he cultivates with such brilliant success." M. Le Blanc was far from being an amateur, and Gauss was soon aware of it. His answer contained a warm recognition of her talents, and a friendly intercourse was kept up between them for several years without his becoming aware of the sex of his correspondent.

In 1808 Sophie Germain contended for the prize offered by the Institute for the best memoir giving the mathematical theory of elastic surfaces and comparing it with experience. She deduced the equation of these surfaces from a certain hypothesis concerning the forces of elasticity, but there was an error in her mathematics, and her equation was not correct. Lagrange, to whom the paper had been referred, deduced from the same hypothesis the equation which is still recognized as the correct one. Sophie did not receive the prize. Two years later she sent in a second memoir, in which the same equation is correctly given, and a more complicated hypothesis leads to the equation for the state of things which obtains at the boundaries of the elastic plate. Her theoretical solution she had also confirmed by a long series of experiments. This paper received honorable mention. Nothing daunted, she tried a third time and received the prize, although the commission was not absolutely satisfied with the rigor of her demonstration. Germain's equation for elastic plates is still the fundamental equation of the theory. Her boundary equations have not stood the test of time; fourteen years later Poisson gave a different set of boundary equations based upon a different hypothesis, and in 1850 Kirchoff showed that neither hypothesis was tenable and that neither set of equations was correct.

In 1824 she sent another paper to the Institute entitled, "On the Employment

of the Thickness in the Theory of Elastic Surfaces." This paper was given to a commission consisting of Poisson, Prony, and Laplace. They never brought in their report, and Sophie was never able to regain possession of the manuscript. Only a few years after her death it was discovered among the papers of Prony and it was reprinted entire in a supplement to Liouville's *Journal des Mathématiques.*

Not spoiled by her success, Sophie Germain continued her studies with all her former enthusiasm. She attended the sessions of the Academy of Sciences, kept herself abreast of the scientific researches of her contemporaries, and found time to perform various friendly offices for her acquaintances. She contributed to the *Annales de Physique et de Chimie* an examination of the principles which lead to the laws of movement of elastic solids. In this paper she establishes, in opposition to Poisson, that no hypothesis in regard to the molecular constitution of bodies is necessary in a discussion of elasticity. Her views on this subject have been confirmed. Two papers of hers in *Crelle's Journal*—one on the curvature of surfaces and one on the theory of numbers—were composed by her during the noise of the cannon of the July 1830 revolution. Her hope of finding a profound absorption had not been disappointed.

There are many testimonials to the charm of her character and of her conversation. She was imbued with a pure love of science and was remarkably indifferent to her own fame. She rejoiced when ideas which she had let fall in conversation were appropriated by others. It made no difference, she said, from whom an idea came; it was only of consequence that it should be true and useful. Fame she defined to be the small space which one occupies in the brains of his neighbors—a definition which Schopenhauer later repeated. Virtue she looked upon as a sense of order, which the cultivated understanding must admire, even when the heart does not love it. Her conversation was full of gaiety and freshness and bore constant marks of originality of thinking and of a poetic handling of her thoughts. She died at the age of fifty-five. Her grave is at Père Lachaise, near that of Comte.

The philosophical writings of Sophie Germain were given to the world two years after her death by her nephew Lherbette. Besides some detached thoughts, they consist of a long article entitled "Considerations on the State of the Sciences and of Letters at the Different Periods of Their Culture." Her main idea is the extension of the principles of law and of the harmonious interaction of causes which prevail in the physical sciences, to the regions of politics, of morals, and of art—the same idea which Comte expounded with much greater detail in his *Cours de Philosophie Positive.* Comte's indebtedness to Condorcet and to Saint-Simon has frequently been mentioned. It is only recently that it has been discovered how distinctly he was anticipated in the main features of his system by Sophie Germain. Dühring, in his *Critical History of Philosophy from Its Beginnings to the Present Time* (3rd ed., Leipsic, 1878), says, after giving a full abstract of her work: "One sees from the above that the Positivism which, without the use of the word, one finds in the writings of Sophie Germain, contains the essential features of that which has hitherto been associated with the name of Auguste Comte." The *Zeitschrift für Philosophie* has had two long articles by Göring entitled: "Sophie Germain as the Predecessor of Comte." Her "Considerations" are still very interesting reading, even in times like ours.

IRA REMSEN AND ROGER ADAMS— A CHEMICAL CENTENNIAL

By WINSLOW H. HARTFORD
MUTUAL CHEMICAL COMPANY OF AMERICA, BALTIMORE

THE year 1946 marks the one-hundredth anniversary of the birth of Ira Remsen, first professor of chemistry and second president of The Johns Hopkins University. The chemists of Maryland, through the Maryland Section of the American Chemical Society, have appropriately chosen this year to initiate a series of lectures in his honor, and Professor Roger Adams of the University of Illinois was selected as the first Remsen Lecturer.

The first lecture, ''Chemical Research in the War and Post-War Period,'' was given in Remsen Hall of Johns Hopkins University on May 24.

Behind this statement of academic activity lies a story reflecting in miniature the transfer of supremacy in chemical attainment from Germany to the United States, and with it in great measure the technical skill which spelled success for the United Nations in World War II.

Ira Remsen was born in New York City on February 10, 1846.[1] Following a public school education and a partial course at the Free Academy—now the College—of the City of New York, he was apprenticed by his father to a medical man who taught at a homeopathic medical college. This instruction proved woefully inadequate, but in Remsen's insatiable reading the seeds were sown for his eventual career in chemistry. As Remsen related in one of his many addresses in later years:

While reading a textbook of chemistry, I came upon the statement ''nitric acid acts on copper.'' I was getting tired of reading such absurd stuff and I determined to see what this meant. Copper was more or less familiar to me, for copper cents were then in use. I had seen a bottle marked ''nitric acid'' on a table in the doctor's office where I was then ''doing time.'' I did not know its peculiarities, but I was getting on and likely to learn. The spirit of adventure was upon me.

Having nitric acid and copper, I had only to learn what the words ''acts upon'' meant. . . .

IRA REMSEN, 1846–1927
THIS PHOTOGRAPH WAS TAKEN IN 1922.

All was still. In the interest of knowledge I was even willing to sacrifice one of the few copper cents then in my possession.

I put one of them on the table; opened the bottle marked ''nitric acid''; poured some of the liquid on the copper; and prepared to take an observation. But what was this wonderful thing I beheld? The cent was already changed, and it was no small change either. A greenish blue liquid foamed and fumed over the cent and over the table. The air in the neighborhood of

[1] For this and other biographical information, the author is indebted to F. H. Getman's *Life of Ira Remsen*, Chemical Education Publishing Co., Easton, Pa.

REMSEN HALL AT JOHNS HOPKINS

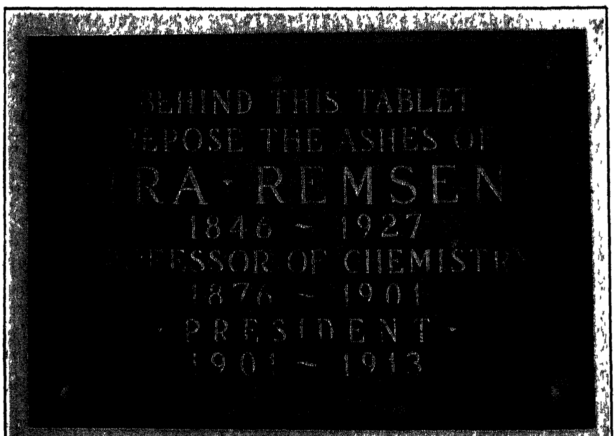
> the performance became colored dark red. This was disagreeable and suffocating. How should I stop this?
>
> I tried to get rid of the objectionable mess by picking it up and throwing it out of the window, which I had meanwhile opened. I learnt another fact—nitric acid not only acts on copper but it acts upon fingers. The pain led to another unpremeditated experiment. I drew my fingers across my trousers and another fact was discovered. Nitric acid acts upon trousers.
>
> Taking everything into consideration that was the most impressive experiment . . . I ever performed. . . . It resulted in a desire on my part to learn more about that remarkable kind of action. Plainly, the only way to learn about it was to see its results, to experiment, to work in a laboratory.

During this "medical instruction," Remsen was also asked to aid his teacher in presenting chemical experiments which neither he nor his teacher had ever performed or seen. The results can be imagined. Such instances were typical of American chemistry and chemical instruction in 1865. Only a few trained chemists were teaching anywhere in the country. Dr. Charles A. Browne writes:

> The effects of the Civil War on chemical education in America were in the nature of an overwhelming catastrophe. Professors and pupils were called from their laboratories . . . and the tide of progress was turned backward for twenty years. . . .

It may be remarked parenthetically that problems arising from the drafting of scientists are evidently not new.

In contrast, in Germany a great upsurge of chemical activity was taking place. With the coming of the year 1860 the groundwork of modern chemistry had been laid, and the laboratories of the great German universities were peopled with men who were giants in their profession. The golden age of German chemistry, which was to hold undisputed sway until 1914, had begun. It was the work of the students of these men—Liebig, Bunsen, Kékulé, Kirchhoff, Wöhler, Hofmann, Volhard, and others—that created the great German chemical industry with which Kaiser Wilhelm II sought to feed his war machine in World War I and that remained a potent factor in Hitler's plans until strategic bombing virtually destroyed it. Although Remsen dutifully completed his medical studies, transferring to the Columbia College of Physicians and Surgeons where he re-



From the Journal of Chemical Education

PLAQUE IN REMSEN HALL

ceived an M.D. in 1867, he never practiced this profession. Soon after his graduation he sailed for Germany to follow his suppressed bent for chemistry and to gain inspiration from the wealth of genius then in the German universities. After studying for some time under Volhard at Munich, he received his Ph.D. for work with Fittig at Göttingen in 1870. He remained in Germany for two years as Fittig's assistant and returned to the United States in 1872, seeking opportunity in teaching and research.

After a period of bitter discouragement, during which he completed a translation of Wöhler's German text on organic chemistry, Remsen accepted a teaching post at Williams College in Williamstown, Mass. Here he found meager facilities—no research laboratories—for the college expected chemistry to be taught in the classical tradition as a cultural subject. So talented an instructor was young Remsen, however, that the college later yielded to his request for a research laboratory. Here he continued the work he had started in Germany, and it was while he was at Williams that he wrote his *Theoretical Chemistry,* which was the first of eight textbooks written by him. These went through as many as eight editions and were translated into German, Italian, French, Russian, Finnish, Polish, Chinese, and Japanese. It was in this connection that Dr. Isaiah Bowman, president of The Johns Hopkins University, said at the first Remsen Memorial Lecture:

> The total of these figures [the sale of Remsen's textbooks] is close to half a million and if we consider how books are often bought and resold by students it is clear that something above seven figures measures the number of students who used Ira Remsen's textbooks. That is almost equal to the prewar enrollment of all the colleges and universities in the United States —truly a great host. . . . It is well within the truth, therefore, to say that millions of students in practically all of the scientifically progressive countries of the world studied in the laboratory and felt the intellectual impulse of Ira Remsen.

On the death of Johns Hopkins in 1873, it was revealed that his will provided the sum of $7,000,000 for the founding of a hospital and university. The work that Professor Remsen had done at Williams had made him a well-known figure in American chemistry, and in 1876 he was offered and accepted the position of Professor of Chemistry at the new Johns Hopkins University in Baltimore. Just as this university pioneered in graduate studies in science in America, so Ira Remsen became the leader of modern American chemistry. Dr. Benjamin Harrow says in his book *Eminent Chemists of Our Time:*

> Remsen was the first professor of chemistry at the first institution ever established in America for graduate work—Johns Hopkins. . . . As teacher, as research worker, and as a writer he is more directly responsible for the development of the science in the United States than any other man.

From 1876 until he became President of the University in 1901, Remsen gloried in a quarter-century of research and teaching which has had few equals in its effects. Among his students were such men as Professor James F. Norris, of M.I.T.; Professor Lyman C. Newell, of Boston University; Professors E. Emmet Reid and J. W. Frazer, of Johns Hopkins; Professor W. A. Noyes, of the University of Illinois; and many others who passed on the inspiration given them by Remsen. It was due in large measure to the work of Remsen's students that when World War I cut off the supply of German chemicals, medicines, and dyes American chemistry rose to the occasion and met the nation's needs.

His research for the most part proved Remsen a chemists' chemist. He authored or directed work leading to the publication of some 156 papers, most of them solid contributions to the fundamental knowledge of organic chemistry, that branch of science which yields us dyes, medicinals, insecticides, lacquers,

plastics, and most of the modern "synthetics" which have aided man's progress through the years.

The extent to which Remsen was concerned with fundamentals is best illustrated by an anecdote regarding his discovery of benzosulfimide, or saccharin. This compound was investigated by Remsen and a graduate fellow from Germany named Fahlberg. The usual scientific paper was published, and Remsen went on to correlate the reactions of the new compound with those of other similar organic compounds. Fahlberg, however, was an opportunist if ever there was one and promptly applied for a patent on the material and obtained it. Fahlberg assigned half his rights to a German concern with which he entered into partnership for the manufacture of saccharin. Although his many friends urged Remsen to contest the patent, he never did so. "I did not want his [Fahlberg's] money," said Remsen, "but I did feel that I ought to have received a little credit for the discovery."

Although the general public may remember Remsen as the president of The Johns Hopkins University, where he served from 1901 to 1912, and Baltimoreans will recall his public service on the Baltimore School Board, the Good Roads Board, the Sewage Commission, and President Theodore Roosevelt's Pure Food Board, it is as an outstanding

ROGER ADAMS AND ISAIAH BOWMAN

AT THE DINNER TENDERED DR. ADAMS BEFORE HIS REMSEN MEMORIAL LECTURE.

PRESENTATION OF THE REMSEN LECTURESHIP AWARD

GILES B. COOKE, CHAIRMAN OF THE MARYLAND SECTION OF THE AMERICAN CHEMICAL SOCIETY PRESENTS THE SCROLL SHOWN BELOW TO ROGER ADAMS, UNIVERSITY OF ILLINOIS, THE FIRST REMSEN LECTURER.

chemist that he served his country best. His own profession honored him: with the presidency of the American Chemical Society, the American Association for the Advancement of Science, and the National Academy of Science. He received many medals and honorary degrees as well.

Ira Remsen died on March 4, 1927, at the age of eighty-one. His ashes rest in an urn sealed in the wall of Remsen Hall at Homewood.

It is fitting that the Maryland Section of the American Chemical Society should create the Remsen Memorial Lecture Award as a recognition of American chemists whose attainments continue the distinguished pattern that Ira Remsen created. It is particularly fitting that Professor Roger Adams should be the

Presented to

Roger Adams

on the occasion of his

Remsen Memorial Lecture

sponsored by

The Maryland Section of the American Chemical Society

in memory of

Ira Remsen

Teacher, Investigator, Author, Administrator

May 24, 1946

first Remsen Lecturer. For, as Ira Remsen brought to this country the genius of German chemists of the seventies and laid the foundations of modern American chemical research, so Roger Adams completes the cycle. It will be largely his responsibility, as Chairman of the FEA Committee on Chemical and Engineering Research Control in Germany and as Scientific Advisor to the Deputy Military Governor of Germany, to determine the future of German chemical progress. Trained chemists and a fundamental chemical research program are today as much a part of a country's resources as steel or oil or food. This Professor Adams must bear in mind in his inspection of an industry once great and now badly damaged by strategic bombing attacks. Few will deny that the final victory of the war was a victory of Allied scientific and technical achievement as well as of Allied manpower and yet one in which inspections within Germany have revealed an uncomfortably narrow margin of supremacy. Recommendations for the continuance of German scientific work cannot fail to be greatly influenced by the opinion of Dr. Adams. It is in the hands of men of his stamp that the future of Germany may well rest.

Like Remsen, Dr. Adams has achieved distinction in his profession. He has been president of the American Chemical Society and is now Chairman of its Board of Directors. He has received the Nichols Medal, the Davy Medal of the Royal Society of London, and this fall will receive American chemistry's highest award, the Priestley Medal of the American Chemical Society. Honorary degrees have been conferred on him by the Polytechnic Institute of Brooklyn, Northwestern University, The University of Rochester, and Harvard University. Professor Alsoph Corwin, Chairman of the Chemistry Department of The Johns Hopkins University, in introducing Professor Adams, said of him:

> In the fall of 1910 . . . the first scientific paper appeared in which Roger Adams was coauthor. This initiated one of the most remarkable records of chemical publication in existence. During the past three decades, he has published solid, scholarly contributions to the science and art of chemistry at the sustained average rate of one a month.
>
> . . . First of all, he is a chemists' chemist. He has made numerous contributions to the techniques of the laboratory, improving methods of identification and preparation of new substances, devising new methods of synthesis and in general lightening the load of the practitioner of the art. He has made extensive contributions to our understanding of chemical reactions, chemical structures and chemical theory. . . . These things are the bread and meat of the contemplative scientist seeking understanding. . . Outstanding in this field is his classical study of the structure and synthesis of substances useful in the control of leprosy. It is difficult to overestimate the significance of this total contribution in terms of human comfort and human welfare.

This, in brief, is a picture of the man whom Maryland chemists are honoring in the name of Maryland's great chemist, Ira Remsen. His talk to the Maryland Section of the American Chemical Society on the occasion of the presentation of the Remsen Memorial Lecture Award was a reminder not only to chemists, but to the American people, of the vital significance of chemistry in the present political and economic picture.

Of Germany, Professor Adams says, in part:

> Research in Germany was stopped abruptly on V–E Day. In the United States zone permission was given by the AMG for the resumption of a limited amount of research in one or two industrial concerns in specified fields of chemistry. A law for the control of research has just been promulgated which will make it possible for the resumption of both industrial and academic scientific research under supervision. . . . However, it is difficult to envisage how any extensive research program can function in the near future. Many of the plants of the I. G. Farbenindustrie, which employed 90 percent of the German chemists, will probably be destroyed or

eliminated through reparations, and there will be left merely smaller industrial chemical units competitive in character. The money available for both academic and industrial research will be much more restricted than before the war. . . . For some time to come it will be impossible to obtain glassware, physical equipment, and many of the needed chemicals. With conditions of semistarvation, lack of fuel, clothing, and other necessities of life in addition, the German scientist will be working under unbelievably difficult circumstances. The ideal conditions that existed in Germany for facilitating research and for investigators are gone and perhaps may never be recovered. But the will to succeed has not yet disappeared, and scientists, notably ambitious, will do their best to produce with whatever facilities are available to them. It is the current belief among German scientists that they as a class have a major responsibility to again bring their country to a leading position.

Thus we trace a full swing of the pendulum in chemistry: from the student days of Ira Remsen when Americans brought the beginnings of a great industry to this country from the great talents of German universities; to today when men like Professor Adams signify the commanding position to which American chemistry has risen.

In Professor Adams' talk to the Maryland chemists he detailed many of the great wartime chemical discoveries, culminating in the chemistry of new elements such as plutonium and its part in the atomic bomb project. But in closing he speaks for the scientific future of America:

Progress in applied science depends on advance in fundamental science. The power of science in the United States will be no more effective than the quality of our teachers and students who create the background for future industrial discoveries Once again I quote Kapitza [P. L. Kapitza, the world-renowned Russian physicist and Russia's most distinguished scientist] who pleaded for recognition of fundamental science and its importance: "We, however, are often apt to judge scientific attainments only by their practical results and consequently it appears as if the person who picked the apple had done the main job, while in actual fact, the apple was created by the person who planted the tree."

The strength of a country has depended in the past on its possessions, in earlier days on land, its control of transportation and waterways, or its supply of raw materials, but today a nation's strength will be largely in the quality of its scientists. Governments must support the work of scientists but not control it in such a way as to hamper development or to direct it into military channels. . . . Nuclear energy, the scientific discovery of the present day which has shown its power to destroy, will undoubtedly be turned from instrumentalities of war to applications for the welfare of all.

PLANT PROTECTION IN THE BELGIAN CONGO

By R. L. STEYAERT

INSTITUT NATIONAL POUR L'ETUDE AGRONOMIQUE DU CONGO BELGE

To WRITE for Americans even the shortest account of the work accomplished in plant protection in the Belgian Congo it is necessary to give first an insight into the history of the country itself.

Only a little more than seventy years ago this country of a million square miles was *terra incognita*. The last large area to be opened to civilization, it now has 50,000 miles of roads, 3,000 miles of railroads, and 8,000 miles of navigable rivers. Its population is about 14,000,000, including 35,000 Europeans, and it has the highest trade figure per capita in tropical Africa.

Through the discoveries of Henry M. Stanley in the Congo Basin and the enterprise of Belgium's King Leopold II, who enlisted his services, the Congo Free State was founded in 1885 under Leopold's sovereignty. In 1908, a year before the King's death, the Free State became a colony of Belgium.

Agricultural development in the Congo Free State was delayed by many problems involved in opening the country. The energy of the newborn state was taxed to the utmost by a war against Arab slave traders in the eastern half of the country, by the pacification of a motley array of warring tribes, by the organization of inland river transports, the building of a railroad from Matadi to the Stanley Pool in an almost impenetrable country, and the fight against sleeping sickness. It was only at the turn of the century that agricultural experiment stations were founded, including a botanical garden in Eala. This garden, established by the Belgian botanist E. Laurent and ably managed by Pynaert, played a significant role in the importation of plants and seeds. At the same time a hothouse garden was built on the King's property at Laeken. To all intents and purposes it functioned as a quarantine station.

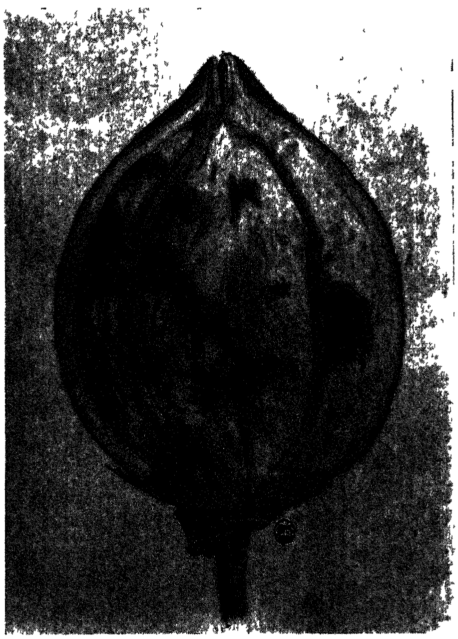
After 1908, with the support of the home country, the agricultural service was organized and a small scientific staff was engaged. This encouraging beginning was dashed by the disaster of World War I. The staff was depleted, and the men who departed could not soon be replaced. During the German occupation of Belgium all the universities and specialized colleges had had to close their doors at one time or another. Thus, not only were there no men to impart knowledge gained by experience,

STUNTED COTTON PLANT
DAMAGED BY *Helopeltis bergrothi.*

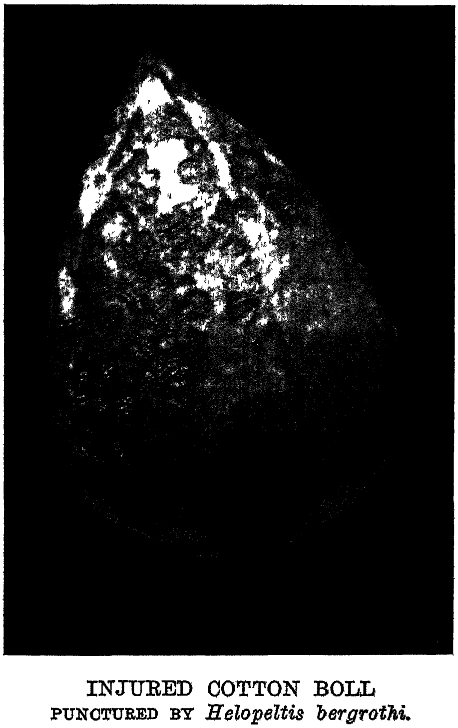
but there were also no responsive young men. The aftermath of the war was not wiped out until the late twenties, when men and capital had come to the colony. From that time dates the true agricultural development of the Congo.

At present three crops dominate the agricultural economy: two indigenous plants, oil palm and coffee; and an imported one, cotton.

Cotton. In the scale of importance cotton ranks high, not only economically but politically. Cotton fits perfectly in the rotations practiced by the natives. Moreover, it is an easy cash crop. With this in mind the Administration put cotton under a special status. Paradoxically, though this crop adapts itself well to the shifting conditions of native agriculture, it stabilized the natives themselves by stopping migrations. Regions far away from any navigable rivers or railroads were given a paying crop,



STIGMATOMYCOSIS
COTTON BOLL ATTACKED BY INTERNAL BOLL ROT.



INJURED COTTON BOLL
PUNCTURED BY *Helopeltis bergrothi.*

thanks to a rapidly developing network of roads. Furthermore, an unexpected result was that food crops were better and more extensively planted.

Land freshly cleared for cotton bears one or two crops of food plants—corn (maize), rice, or peanuts—as such lands, especially forest soils, are unsuitable for cotton. No wonder, then, that for fifteen years most of the efforts in the development of agriculture were concentrated on this crop. Introduced experimentally in the Lower Congo (estuary of the river) before the first world war, it failed. A new site chosen in the Maniema (east-central Congo) gave much more promising results, but the real development of cotton dates from its introduction into the Uele district in northern Congo. Experiment and research stations mushroomed immediately. Subsequently their number was somewhat reduced, but at present two major and six semipermanent stations are operating. This network is further extended by

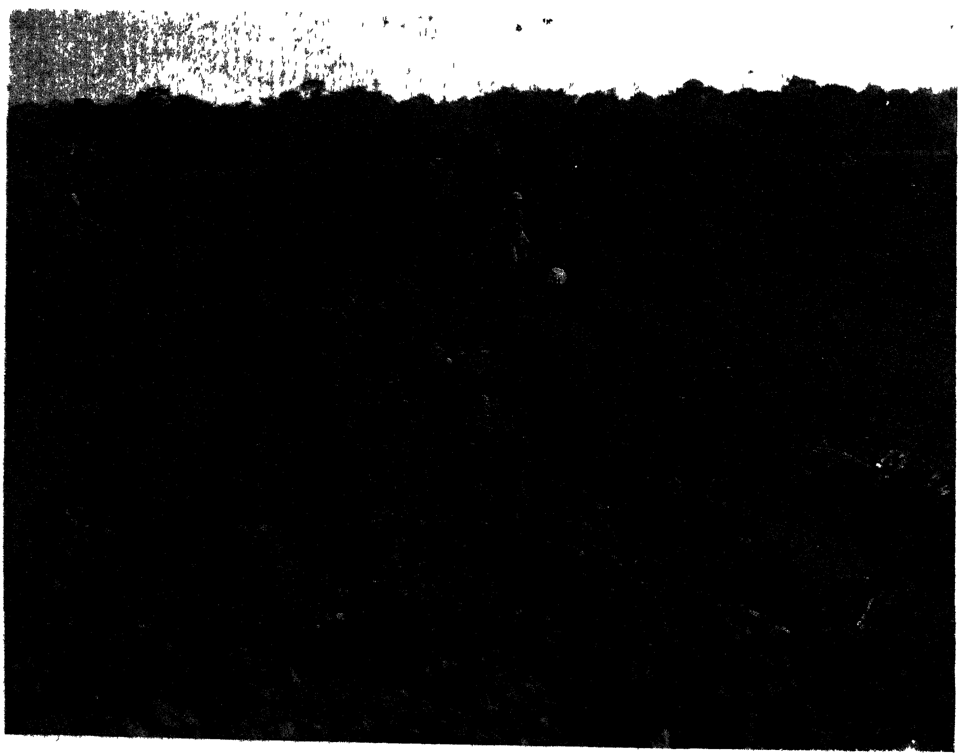
"local experiments" in the care of official itinerant agronomists. Progressively, cotton was extended to the savannas south of the equator in the Sankuru district, and by 1938 the production of this part of the colony equaled that of the northern cotton belt. The existence of two cotton belts on either side of the equator is a fortunate circumstance for the national economy, enabling a steady export the whole year round To illustrate the rapid progress made in the cultivation of cotton, the production of seed cotton in the Belgian Congo is given hereunder in metric tons at five-year intervals:

1923	1,812
1928	14,255
1933	46,264
1938	127,488

In 1940 the production was about 145,000 tons.

Development of cotton has been described in some detail as it accounts for the large amount of work done on the insect pests and diseases of that crop.

Oil palm. The oil-palm industry started during the time of the Congo Free State. To entice capital investments into this barely explored land, monopolies on big zones had been granted, but they concerned solely the buying from the natives of fruit picked from wild plants. No thought had been given to methodical cultivation of the oil palm in plantations. Why do so? Wild palms could be found in plenty, giving an immediate income with little capital outlay. Under stress of international competition such easy methods of exploitation had to be gradually abandoned. Like the seeds of many other plants, those of the oil palm found



COTTON DESTROYED BY *HELOPELTIS BERGROTHI*

their way to the Dutch East Indies. Within a few years the Dutch had selected high yielders and were setting up a menacing competition. In production of palm oil the Belgian Congo found itself in danger of being in a position like that of Brazil with respect to Hevea rubber. Determined not to be outdistanced by the Dutch, the Congo had to adopt more orthodox methods of agriculture. Therefore the Department of Agriculture established a research station close to an already existing government-owned Hevea plantation in Yangambi. In the last decade, with the increasing availability of mass-selected seeds and selected strains, plantations, both European and native, have been cropping up all over the colony.

Tropical agriculture owes to A. Beirnaert invaluable knowledge on the genetics of the oil palm. Breaking ground in its selection, he developed the Tenera hybrid by crossing Dura and Pisifera types. His work remains an outstanding tribute to his memory. The Congo suffered an immense loss when he was killed in 1941 in a motor accident.

Coffee. What has been said of the oil-palm industry applies to the coffee industry, except that the latter has never depended on wild coffee, which is not acceptable to the trade. Coffee was one of the first wild plants to be regularly cultivated, and the Congo Free State encouraged it in every way. However, so many species could be found wild that prospective planters were in a quandary as to which to select, *arabica* coffee having been ruled out by climatic conditions. As happens more often than not in such cases, the wrong ones were planted. Here also one of the Congolese species made its way to Java, where it superseded *arabica* in the low-lying districts. This coffee came to be known as *robusta* (*Coffea canephora* Pierre) in recognition of its resistance to Hemileia rust. Incidentally, *robusta* brought with it to Java its most troublesome pest: the coffee-berry borer (*Stephanoderes hampei* Ferr).

OIL PALM TREE
ATTACKED BY FUNGUS, *Ganoderma lucidum.*

Unquestionably the Dutch have taken a lead on us in selection of *robusta*. But some of the Java-selected strains have come back to their homeland, and, with the help of those locally produced, many plantations were established after the first world war. Unfortunately, with overproduction looming ahead, the government in 1938 had to limit the increase in acreage. The coffee industry is steadily recovering though, thanks to the guidance of a Coffee Board. Very noticeable improvements in the exports have been recorded of late.

Other crops. In the early days of the colony cacao was for a time in favor with planters, but severe competition from the Gold Coast dampened all further efforts to develop this crop.

On the other hand, Hevea rubber,

ROOTS OF HEVEA
EXPOSED FOR THE CONTROL OF *R. microporus.*

though introduced long ago, was shunned for many years. It is only since 1935, and more especially under the urge of war needs, that it has come into prominence. Expansion of Hevea rubber production might be seriously impaired, however, by conditions that will be mentioned later.

Many other products, such as corn, peanuts, rice, an indigenous fiber, *Urena lobata,* citrus, banana, and sisal, are being exported in increasing quantities or are being developed for local consumption.

BESIDES the low-lying central plains, whose crops we have discussed, other agricultural districts are situated on the high plateaus bordering the Congo to the east and southeast. In the southeast we have the Katanga plateau, extending roughly between the seventh and fourteenth parallels south, and in the east the Ituri, Kivu, and Ruanda-Urundi plateaus straddling the equator between the third parallel north and the fourth parallel south. In the Katanga a six months' dry season divides the year into summer and winter seasons. The eastern plateaus enjoy two rainy seasons per annum, with a break in the rains, or a dry season of one, two, or three months, according to the remoteness from the equator. The equable or mild climate of these plateaus leaves some prospects for a limited white settlement.

The opening and exploitation of the Katanga copper mines attracted quite a few settlers, and, supplies being scarce, many farmed corn until the railroad from Bas-Congo to Katanga linked the mining districts with those densely populated in the plains. Settlers switched over then to market gardening and fruit and dairy farming, for the products of which they find a ready market in local industrial townships.

The Ituri and Kivu began to be settled only in the middle twenties, settlers concentrating around Lake Kivu and in the northern Ituri. Most planted *arabica* coffee, but in the vicinity of the Ituri gold mines corn and beans were grown. Lately, however, with the rapid development of roads, they too switched over to market and dairy produce, exporting butter, cheese, and vegetables to such faraway townships as Stanleyville, Buta Aketi, and Leopoldville. In the Kivu, cultivation of pyrethrum and Cinchona has developed in the last few years.

The rapidly developing agriculture of the colony has thus been sketched out. If the results are gratifying, many problems remain to be solved, the most urgent being a proper rotation for native agriculture. Not only is it a question of soil conservation but it is also, and perhaps primarily, a forest-conservation problem.

Precariously situated between two big deserts, the central African jungle needs

careful management if the steady encroachments of the northern and southern savannas are to be stopped—an encroachment which many African tribes have encouraged by their deplorable agricultural practices and bush fires. To counter this a system of jungle fallow, aiming at a rapid reintroduction of forest trees in abandoned fields, is being studied.

Until a decade ago progress was gained by rough-and-ready methods, but further progress was barred without a more scientific knowledge of local African conditions than then existed. To meet this need a research institution was founded in 1934, under the name "Institut National pour l'Etude Agrônomique du Congo Belge" (INEAC for short). Within this new institution the government incorporated all its experimental stations and scientific staff, retaining only those civil servants indispensable for administrative purposes. The INEAC is liberally organized for ease of scientific and financial operations.

In 1940 the staff for the whole institution numbered about ninety, but it was severely reduced during the war by mobilization and deaths and by members on leave in Belgium who were unable to return because of the invasion. The institution is managed by a committee sitting in Brussels, composed of university professors and leading scientists, and by a Director General whose residence in Africa is in Yangambi.

In this organization the Division of Plant Pathology (including entomology) now has three laboratories in the following stations: Bambesa, Mulungu, and Gandajika. A fourth one was under construction at Yangambi in 1940, which would have been, but for the war, the central laboratory of the Division.

We have said that in 1908, when Belgium annexed the colony, a Department of Agriculture was organized. This new department immediately engaged specialists. R. Mayné, the first entomologist, arrived in 1911. F. Vermoesen, having traveled in the East, arrived in the Congo as mycologist, but his inclinations went to botany, and he did very valuable work by describing the principal trees of the Mayumbe forest. Unfortunately, he suffered from ill-health and soon had to leave the service and died in 1922. Mayné kept on until 1921 when he was called upon to fill the vacant professorship of zoology and entomology at the State's Agricultural College of Gembloux. During his sojourn in Africa he was primarily concerned with insect pests of cacao, which he investigated in great detail. The results of his researches were published in London in 1917 by the Belgian government-in-exile. In 1919 J. Ghesquière, at the time recently demobilized from the army, with which he had gone through the whole war, came to the Congo as entomologist. First stationed in the Katanga where he discovered many important insect pests, including *Phthorimaea operculella* Zell. and *Icerya purchasi* Mask., he went ultimately to the Maniema district to investigate the pests on recently introduced cotton.

BAMBESA
THE LABORATORY OF PLANT PATHOLOGY.

With Mayné gone, Ghesquière was left alone to cope with an ever-increasing number of pests as the agriculture of the Colony developed. To alleviate the load somewhat, C. Seydel, an amateur lepidopterist, was engaged. From his arrival in 1923 till his retirement in 1939 he was stationed in the Katanga. Due credit must be paid him for the very good work he accomplished in his own specialty.

Ghesquiére greatly enlarged the field of investigation. To him, seconded by his wife, we owe a considerable increase in the knowledge of the distribution of most of the economic insects. In addition to his work in entomology he collected intensively for natural-history museums and botanic gardens. In 1939 he resigned from government service.

Also in 1919 P. Staner, a mycologist, become the first of a series of postwar graduates that were to come to Africa. Unfortunately, he had to resign for personal reasons in 1929. His resignation was indeed a loss as the mycological aspect of plant pathology had scarcely been investigated. It was only with the specialists engaged in 1929 that at last some sort of permanency in the staff was established. In that year the author as mycologist, followed within a few months by Bredo as entomologist, came to the colony. J. Vrydagh as entomologist and Mrs. Soyer as part-time phytopathologist came in next. In 1932 Leroy arrived as entomologist, followed by the entomologists P. Lefèvre in 1932, P. Henrard in 1934, and the mycologists F. L. Hendrickx [sic] in 1938 and J. Moureau in 1940. This staff, with the exception of Leroy, who resigned in 1935, is still on active service. Most of them were stationed in the Eastern Province (now Province Stanleyville) and have gone elsewhere ultimately. Bredo stayed as government entomologist and has been lent to the International Locust Research Board, managed from the Imperial Institute of Entomology in London. Stationed in Abercorn, Northern Rhodesia, he has been mainly concerned with the study of *Nomadacris septemfasciata* Serv. Since the end of World War II we have been able to add three new entomologists to our staff.

Some Insect and Plant Disease Problems

Cotton. In 1930 and 1931 a most severe invasion of *Helopeltis bergrothi* Reut., a mirid bug previously reported on cacao but hitherto unknown on cotton, caused the loss of one-third of the cotton crop. At the same time pink bollworm, *Pectinophora gossypiella* (Saund.), was also discovered, carried into the Congo most probably by the eastern trade winds blowing from the Anglo-Egyptian Sudan. The menace of these two pests sufficed to justify the building of a properly equipped laboratory at the Bambesa Cotton Experiment Station in the Uele district.

The latter pest was soon found to have much less importance than in Egypt, as the work of the new laboratory showed that the insect had no diapause (period of inactivity) under tropical conditions. The seeds being thus noninfective, compulsory seed disinfection with Simon's hot-air machine was waived. On the other hand, stress was laid on the establishment of a closed season devoid of all cotton plants in the field. It is now illegal in the Northern Congo to grow cotton from March till July. This has plainly proved to be the best control measure.

In the southern cotton belt, pink bollworm is unknown except in the Ruzizi Valley, connecting Lakes Kivu and Tanganyika, but bollworm, *Heliothis armigera* Hübn., is sometimes destructive.

Concerning the *Helopeltis* pest very little new knowledge has been gained, the chief reason being that no new severe outbreak has occurred in the Uele district. Sporadically and in limited zones severe outbreaks do occur but are so unpredictable that no research program has been possible. At present control is limited to hand-picking, and premiums are paid in salt, for which the natives are very eager. Hand-picking of the first generation of the insects, invading cotton when it is one or two months old, is especially

stressed. Apparently climatic conditions play an important role With the development of the weather survey in recent years it has been noticed that certain regions where *Helopeltis* outbreaks are frequent have a climate differing from the rest of the cotton belt.

A leaf disorder called *frisolée* was described in the early days of cotton, but it was not until 1934 that the insect vector was found to be *Lygus simonyi* Reut. Damage is very severe on newly cleared land—one of the reasons why food crops are planted before cotton. In the southern cotton belt damage is even more severe than in the North, notwithstanding the fact that it is mainly savanna country. Discrepancies in the general coloration of the insect might indicate that an undescribed variety or species is involved in the South.

Leafhoppers, mainly *Empoasca facialis* Jac., are troublesome in the savanna regions of both cotton belts, though never a limiting factor. One of the Triumph varieties nevertheless suffers a loss of some 15 percent.

Another major cotton pest is the stainer bug. Several species are involved, the four principal ones being: *Dysdercus superstitiosus* Fabr., *D. nigrofasciatus* Stål., *D. melanoderes* Karsch., and *D. fasciatus* Sign. Not only do these insects damage the plants directly, by puncturing bolls and sucking the immature lint and seeds, but they inoculate yeast fungi, causing a dry rot of the lint. This complex was named "stigmatomycosis" by Nowell, who discovered the complex in the West Indies. It has been one of the major objects of research, efforts being directed principally toward devising a technique for the selection of resistant strains. Very little hope can be held of finding direct means of control. Baits have been tried but have brought little reward.

Efforts are being made to select strains resistant to the fungi, *Nematospora coryli* Peg. and *Ashbya gossypii* (A. & N.) Guill. Artificial inoculations have shown sharp differences in their reactions on the bolls of various cotton strains. Selections for resistance to puncturing have been inconclusive, and unfortunately so, because a cotton repellent to the insect or a puncture-resistant one would be the best solution to the problem.

In 1934 *Verticillium dahliae* Kleb. (hadromycosis) was discovered in the Nepoko, but in 1937 a far more serious disease *Fusarium vasinfectum* Atk. (wilt) was discovered at Bambesa Station, causing considerable alarm. Since then many foci have been discovered, mainly in the eastern part of the Uele district, in northern Sankuru, and in western Ubangi. The primary infections of these foci have been traced in most cases to Wonder Dixie Triumph seeds imported from the United States. To retard the extension of this disease strict quarantine measures have been enforced on the propagation of seed within the territory of the Colony. Selection for resistance, started in 1939, is making good progress and is conducted in fields where fortuitous soil infection is supplemented by artificial inoculations.

Attempts to isolate the toxin or toxins secreted by the fungus have led to positive results with at least one of them: a crystalline product, reproducing the symptoms of the disease in the fibrovascular bundles and the wilting of plants, has been isolated. These researches are being conducted at the Bambesa laboratory. Wilt is a serious menace to the cotton industry as most of the Congo soils are of light texture with a pH below 7—conditions conducive to high virulence in the American biotype of *F. vasinfectum*. Furthermore, climatic conditions and soil temperatures approaching or within the optimum conditions of growth for the fungus exist the whole year round.

Many other pests occur but are of secondary importance. Exception must be made, however, for one recently discovered in the southern cotton belt: *Paurocephala gossypii* Russell, a psyllid. No species of this family had hitherto been recorded on cotton the world over. Its effect on the plant is evidenced by bronzing, shedding of the leaves, dwarfed new growth, and complete sterility. It is the main research problem of the Gandajika laboratory.

Oil palm. This tree suffers from a variety of diseases and pests which have not as yet been systematically investigated. One must bear in mind that the genetically heterogeneous nature of the existing plantations is not conducive to widespread infestations of particular pests and diseases. Undoubtedly, with the progress of selection, diseases and

pests not prominent now or recorded as yet will acquire economic importance. Careful attention is paid, of course, in selection to ward off such dangers. Tests with the best progenies are replicated in as many regions of the Congo as possible, but this by no means lessens the possibility of new diseases appearing or of a recorded one running wild.

At present *Ganoderma lucidum* (Leys.) Karst., a polyporous fungus attacking the roots and trunk, and *Pimelephila ghesquieri* Tams, a moth, seem respectively to be the most important disease and the most troublesome pest. Spike diseases induced by *Fusarium* spp. and *Pestalozzia* sp. are not infrequent, and certain of them may be considered of major importance. The ubiquitous *Armillaria mellea* (Vahl.) Quel. on roots and trunks has been recorded recently. Considerable attention should also be given to deficiency diseases, indicated by leaf chlorosis.

Rubber. The impetus given to Hevea culture forcibly called attention to its diseases. The alarming incidence of root rots in the new plantations is causing considerable concern, for, unless they can be controlled, they might indeed be limiting factors. The foremost culprit is *Rigidoporus microporus* (Sw.) V.O. (syn. *Fomes lignosus* Klotsch.), or white root rot. This fungus is also very active in tropical Asia, but there are indications that its African strains might be much more virulent than those of Asia. Moreover, virulence is enhanced by the propitious conditions of the African environment.

Partial solution of this problem rests probably upon improved agricultural practices. On the other hand, preliminary observations tend to show that such trees as *Blighia Wildemanianna* Gilg., *Celtis* spp., and *Polyalthia suaveolens* Engl. & Diels., after having been felled in the jungle, leave stumps highly susceptible to vigorous invasion by white root rot, and they bear massive outgrowths of sporophores. This might lead to new practices in jungle clearance: ring barking prior to felling, stump poisoning, or even complete removal of stumps might be means of eliminating the foci of infection. Application of soil fungicides might also be considered, and for this purpose the rich deposits of copper ores to be found in the Colony might provide cheap raw materials.

A coreid bug, *Pendulinus devastans* Dist. has been known to cause considerable damage in certain plantations, especially on young trees. Bites from these bugs soon form cankers, killing off the main shoot. Ultimately new shoots appear in a whorl, and these have to be carefully pruned lest the affected trees become misshapen with a bole difficult to tap.

Coffee. *Robusta* coffee has one major pest, *Stephanoderes hampei* Ferr Direct measures of control are hard to devise. This scolytid beetle has the peculiar habit of penetrating the berry exclusively through the flower scar. It is only in the case of infestations so high as to leave none of the berries uninfested that the insect may try to gain access to the berries elsewhere. I have even seen shoots harboring the adults, but in that case the trees were growing in the vicinity of the factory where berries were sun-dried. Most of the life of the insect is passed within the berry, where the eggs are laid and the larvae grow and pupate. The mature beetle leaves the berry at sundown, copulates, and immediately digs itself in again. Control can only be obtained by disrupting its annual life cycle: *Robusta* is grown approximately between the fourth parallels north and south. Although on the equator picking goes on the year round, the farther coffee is planted from it, the more restricted the picking season becomes. There may be a long period wherein few berries mature. These suffice, however, to carry the insect from one season to another. To destroy the insects so carried over a so-called sanitary picking is practiced. A month or two after the regular picking season all berries of sufficient size to harbor the insect are pulled from the trees and burned. It may be necessary to repeat this for a second crop out of season. These control measures have proved to be of great practical value.

Where berries mature more or less evenly throughout the year, control measures are harder to devise, and none of outstanding value has been found as yet. Monthly pickings have been recommended as infestations may run very high, entailing losses of 15, 20, or even 30 percent. Parasites have been studied, especially a fungus, *Beauveria bassiana* Vuill., but, though natural infesta-

tions are very helpful and may reduce the insect population considerably, attempts to increase the natural parasitism by spraying spore suspensions have given insufficient results. The fungus is very virulent to insects feeding on unripe berries, and its virulence is further enhanced by the overcast weather prevalent during the months of June and July north of the equator. Beetles have a very curious reaction to infection. Usually the insect will have bored a gallery to the middle of the berry before the infection develops to any considerable extent. It stops feeding then and begins to crawl slowly backwards until its abdomen juts out from the berry. From the abdomen then develops a pinhead puff of white mycelium bearing by the thousands small spores scarcely 3 μ in size.

Hymenopterous parasites are abundant in some parts, principally *Heterospilus coffeicola* Schmied. and *Prorops nasuta* Water., but very little benefit is derived from their parasitism.

Ants, especially *Oecophylla longinoda* var. *annectens* Wlr., *Macromischoides aculeatus* Mayr., and *M. africanum* Mayr., are big nuisances in coffee plantations. *M. africanum* can inflict such painful bites upon humans that high fevers may ensue. Pickers and pruners exposed to these insects are careful to avoid the infested trees, which, abandoned and unpicked, soon become breeding places for the berry-borer. A satisfactory bait is used against *O. longinoda.* A predacious ant controls the others. Known locally as *badeno,* it is harmless to humans. It suffices to transfer a *badeno* nest to an infested tree in order to rid it in no time of all inimical ants.

Stem-borers, mainly the West African coffee borer, *Bixadus sierricola* White, a cerambycid beetle, can do much damage, though in well-kept plantations where sanitary practices are strictly observed, injections of carbon disulphide into the galleries easily keep the beetle under control.

There is on the whole very little fungus parasitism on coffee, though the white root rot may be very troublesome in places. In west-central Congo around Lake Tumba coffee roots are often attacked by a mealybug, *Pseudococcus citri* Risso. This insect does not seem to be dangerous unless *Polyporus coffeae* Wakef. develops on the exudate. Then the mealybug lives in little cells made of *P. coffeae* mycelium. The fungus itself develops to the point of forming a brownish sheath around the roots. Control is easily obtained by exposing the attacked roots to sunlight for five days, which kills off the fungus. Control of the coccid is then obtained by mixing with the soil, in which the roots are buried again, a certain amount of potassium sulfocarbonate. This chemical decomposes in the soil into carbon disulphide and potassium carbonate, the first being active against the mealybug.

Hemileia rust is practically nonexistent on *robusta* and if present is more an indication of unhealthy conditions of the trees than of true parasitism.

With the development of *arabica* coffee on the eastern plateaus need was soon felt to study its diseases and pests. The troubles of *arabica* coffee are much the same as in British East Africa, with the exception of *Pseudococcus kenyae* LeP., and *Antestia* spp. and *Lygus coffeae* China inflict great losses, the former causing internal rots of the berries and the latter inducing flower abortion. In the former case rots are due to the same fungi that produce internal boll rots (stigmatomycosis) of cotton.

Cacao. The cacao tree, unlike coffee, suffers from a great variety of insect pests and fungi. The whole gamut of root rots is to be found. Armillaria root rot is important and causes the well-known collar-crack. But the most destructive pests are to be found among the insects. Special mention goes to *Sahlbergella singularis* Hag., a scourge of the Mayumbe plantations. This mirid bug, puncturing pods and shoots, not only causes extensive fruit-drop but leaves cankerous and ailing trees.

Sprays and dusts are recommended, but planters are reluctant to apply them as great difficulty is experienced with equipment. Cacao is cultivated under the shade of natural forest trees, and this forbids the use of motor-powered sprayers and dusters. The small back-borne sprayers and dusters would require huge gangs of semiskilled labor. Perhaps with the advent of DDT, a cheap, highly toxic, and easily applied dust will fulfill the requirements. DDT might also be

effective against *Helopeltis bergrothi* Reut., which is second in importance, or against *Heliothrips rubrocinctus* Giard, which causes some leaf-drop.

Cinchona. In the eastern plateaus considerable attention has been paid to Cinchona and its pests. Since the occupation of the Dutch East Indies by the Japanese, considerable efforts have been made to develop this crop in order to alleviate the dearth of the drug. Not only has the Belgian Congo now attained self-sufficiency but increasing quantities of quinine are produced for export. Most of the plantations are concentrated around Lake Kivu on the encircling mountain-flanks. At altitudes from 1,700 to 2,200 meters Cinchona is very heavily attacked by *Helopeltis orophila* Ghesq., which is capable of totally destroying young plantations. This insect seems to be much more destructive than its Asian congeners on the same host. To control the pest, pyrethrum dusts have given very good results. The finely ground flowers are mixed with wood ash, finely powdered and perfectly dried, in the proportion of 1:3 to 1:6. Efforts are made to find resistant clones, if any. Mention must be made also of the honey fungus, *Armillaria mellea* (Vahl.) Quel., which attacks the roots. As it is very troublesome on newly cleared land, the problem might be solved as suggested for Hevea root rots.

Potato. In 1941 and 1942 late blight (*Phytophthora infestans* D.B.), the dreaded potato disease, swept disastrously over Kenya and Uganda and by the end of the latter year got a foothold in Belgian Congo. In 1943 it extended its ravages over the whole of Ruanda-Urundi, the Kivu and Ituri districts, and spread with dire consequences to the native-grown crops. The Administration had introduced the potato as part of a general program of improvement of native agriculture and principally to provide the dense population of the Ruanda-Urundi with a most-needed supplement to their diet. No difficulty at all had been experienced with acceptance of the potato by the natives. In fact, it fell immediately in favor with them. As a result, the potato was widely cultivated and was near to becoming a staple food on a par with beans. This gauges the disaster that the invasion of late blight entailed. It is estimated that 200,000 tons of the potato crop were lost in 1943 in Ruanda-Urundi alone.

Since blight finds suitable environmental conditions in tropical highlands, which have no parallel except in Ireland and in certain districts of the American Atlantic seaboard, the disease is one of the most difficult to control. Bordeaux sprays, which have been standard means of control, have only a limited application under present conditions of native agriculture.

The use of resistant varieties can alone be considered for the time being, but in this we meet one of the most intricate problems of selection applied to disease resistance. A host of workers have tackled the problem in England, Germany, Russia, and America with few outstanding results and at the cost of protracted efforts during many years. Moreover, appearance of local or widespread biotypes of the fungus virulent on formerly resistant strains have impeded selection of universally resistant potato varieties. Knowledge of local biotypes is thus one of the prerequisites for the selection of resistant varieties. Progeny and hybrid selection stumbles in the tropics on a major difficulty. In the tropics short days of eleven to thirteen hours of sunshine prevent, with cultivated varieties of the potato, flowering and seeding, which happens rather freely under temperate climates with longer summer photoperiodicity. Means to by-pass the difficulty are now being studied, and only if it can be solved will selection be possible on an adequate scale. At present a sizable collection of varieties, continually increased as conditions permit, is being tested under blight conditions.

Bacterial rots of tubers have been recorded recently, but, though late blight has been less favored by climatic conditions in the past year, it is suspected that these rots are partly due to a masked epiphytotic of *Phytophthora infestans.* Their prevalence in heavy soils lends support to that assumption.

The foregoing pests and diseases of highland crops are studied by the Mulungu laboratory.

Other Food Crops. Corn, wheat, peanuts, rice, cassava, and sweet potatoes have, of course, an importance of their own, and any

factor that might play havoc with them calls for our diligent attention.

Corn, with its host of varieties, lends itself to widespread cultivation, though in a few regions of the Congo it is unknown or little cultivated. The wide range of climatic conditions prevalent in the Congo accompanies an equally variable scale of pathological problems, but on the whole the foremost diseases and pests are: in the highlands, "streak," a virus, and *Busseola fusca* Fuller, a lepidopterous stem-borer; in the lowlands, *Sclerospora maydis* (Rac.) Palm. Streak, with *Cicadulina mbila* (Naudé) and *Cicadulina* sp. as vectors, has taken year in and year out a steady toll of the crop, especially in the Ituri district. In the same district the stem-borer has exerted considerable damage inasmuch as it finds with two crops a year most suitable breeding conditions.

Sclerospora maydis has been of late prevalent in the Sankuru district, and selection of resistant varieties or strains is in progress. In the same district corn is also subject to a peculiar root disease called *shimbu* by the natives, for which they have superstitions. In this disease are involved a monophlebine coccid, an ant (*Camponotus?*), and a fungus. The pantropical grass weed, *Imperata cylindrica,* is a very active host plant. In fact, the disease is as yet unknown where the weed is not dominant.

As might be expected, wheat is cultivated only in the highlands, and one meets with it an old, unwelcome, and omnipresent acquaintance: "Wheatman's burden," black rust, or *Puccinia graminis* Pers. Though barberry, its only alternate host, is absent in Africa, black rust finds no difficulty in being a scourge and big nuisance, to put it in polite words. Wheat is so appreciated by the natives of the upper highlands that two crops succeed each other at close intervals every year. Stubble and ratoons are bridging hosts that carry over the disease from one crop to another with great ease. Nothing has been done yet in the way of selection for rust resistance, but seeds of resistant East- and South-African varieties have been imported. Leaf-eating ladybird beetles, *Epilachna hirta* Thunbg. and *Epilachna serva* Arr., are the major pests. By skeletonizing the foliage crop yields are reduced. The larvae are sensitive to pyrethrum dust, and efforts are being made to popularize this insecticidal plant for home use.

Rice, cultivated in the hotter districts of the colony, enjoys comparative freedom from diseases and pests. *Helminthosporium oryzae* B de H. can sometimes be troublesome, but the greatest damage is done by birds. Flocks of aggressive and quarrelsome sparrows pluck and suck the seeds in the milky stage. Scarecrows are made of upright branches of *Macrolobium,* whose coarse and thick leaves remain attached after drying. These branches are interconnected by *blekeles* (split vines), and potbellied *mwanas* (children) set them in motion and rustle the leaves by short tugs on the lines. The effectiveness of this contraption differs not a whit from that of scarecrows the world over. The best way to meet the problem is to time planting so that heading of rice and of wild grasses occurs simultaneously. Birds then have two bones to pick instead of one.

Peanuts, cultivated more as a delicacy than as a staple food plant, are apt to be badly infested by "rosette," caused by a virus transmitted by *Aphis laburni* Theob., as researches in Gandajika have shown. Close planting is a means by which infestation can be considerably reduced.

Cassava, on the other hand, is the mainstay of the natives and is even more widely cultivated than corn, but it must be understood that cassava is not as carefully planted and tended as other crops. Planted at the end of rotation intermixed with bananas, it serves not only as a food reserve but as a preparation to fallow. For the former purpose the cassava is admirably suited; roots are dug up at the consumer's fancy over several months. Diseases are relatively unimportant, but they do reach an economic level in places such as Ruanda-Urundi, where the food situation needs careful management. The only economic disease is mosaic, a virus transmitted by *Bemisia gossypiperda* M. & L. var. *mosaicivectura* Ghesq. Among the many varieties of cassava existing in the Congo it should be easy to find some resistant to mosaic.

On sweet potato a sort of "rosette" was discovered in the Ituri in 1939. Though the causal organism has not been determined, a virus is suspected. The sweet-potato weevils, *Cylas puncticollis* Boh. and *Cylas* sp., are

troublesome in some parts, and it is very difficult to control them under conditions of native agriculture.

SUCH are the plant disease and pest problems that are to be coped with in the Belgian Congo. Extending over a wide range of crops and a no less wide range of pests and diseases, much work and research have yet to be undertaken to arrive at a fuller knowledge of them. Some are new and specifically African, though most are pantropical or even universal, but new surroundings and interaction of local conditions cause them to be viewed from unfamiliar angles. A good deal of the work accomplished up to the present has more the character of an inventory or a preliminary weeding out of minor problems than basic research.

The more academic work of fungus and insect collection is far from being neglected. Not only are a mycological herbarium and an insect collection being built up at the central laboratory but much of the collections have gone to national museums and herbaria in Belgium.

Central Africa has an appeal of its own—land of mighty rivers and lakes, of dense forests and sun-scorched savannas precariously situated between huge deserts. Its very nature is a challenge to mankind if these regions are to be called upon to pay their contribution to the world's economics. It will only be able to do so if the existing climax is not thrown off balance. In this rests the challenge. Modern science has given a wealth of knowledge and perfection in tools. It is up to us to muster all available resources to bring to this country wealth and prosperity, to leaven the native peoples into contributing members of mankind. The challenge and the vastness of the problems that confront us, of which plant protection is one of many, call for men conscious of their mission and the path they must tread. This ideal more than repays the many discomforts, petty and big, moral and material, inherent to life under the sun of "Darkest Africa."

Darkest Africa? No more so. "Darkest" is indeed a euphemism, and none but those who have lived and toiled under the sky of Central Africa are fully aware that it is often uncomfortably sunlit and steaming hot.

AN INCIDENT AT AMPFING

By MICHAEL B. SHIMKIN
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On May 3, 1945, the Third Corps Forward Headquarters found itself in Dorfen, a sleepy little town fifty kilometers almost due east of Munich. For the Third Corps the war was over. The Corps on the flanks had pinched off its zone of operations, which on the transparent overlay of the situation map came to a sharp end point around the Austrian border. The staff was not entirely pleased. "It's a darn shame," murmured a Corps Artillery major as he shook his head at the map. "And just when the war was almost getting to be fun."

Public Health Team Number Two, Third Army, had been attached to the Third Corps for ten days. Public Health Teams are not to be found in the Army Table of Organization, especially when they consist of two officers of the United States Public Health Service, an UNRRA nurse in a British uniform, and one private, AUS, driving a springless reconnaissance-and-command car to which is attached a trailer filled with a half-ton of DDT powder. It was a unit dreamed up by the Third Army and accepted by the Corps because it promised to fulfill a need.

In the past ten days our team had surveyed six towns, reorganized public health departments and hospitals, had been in a dozen camps for displaced persons, deloused several thousand people, and, of course, had written many official-sounding reports. During the same period we had come down from Frankfurt, had driven four or more hours each day over roads of every description, and had set up our meager equipment and personal belongings in three towns in order to keep up with the Corps.

Omar C. Hopkins, Senior Sanitary Engineer of the Public Health Service and Lieutenant Colonel to the Army, was gray-templed, soft-spoken; an expert on sanitation from Oklahoma. I was the medical officer, and the guild rules of medicine placed me in charge of the team despite my lower rank. "Hop," as he was known to everyone, and I were now veterans of many a waterless, foodless camp for displaced persons. We had been sent overseas post-haste when it looked as if the Germans would collapse in September of 1944 and then had sat gnawing our fingernails in the UNRRA office in London for six weeks. A deal was finally made between the Public Health Service and the Army, and we were transferred to General Eisenhower's G5, the branch that had been established for military government and civil affairs. We flew to Versailles and from there were passed down on paper and bodily to the Twelfth Army Group, through the European Civil Affairs Division, and thence to the Third Army. We started to operate the day after we reported to its Public Health Branch.

In the beginning we were almost completely on our own, thumbing rides on courier jeeps and trucks and carrying our few supplies. Three medical officers and two sanitary engineers were supposed to cover the civilian public health activities in the ever-shifting Third Army area. We were attached, detached, transferred, and just sent to more units than we will ever remember. Most of the time all we could do was inspect, evaluate, and report and tackle only the most pressing emergencies. The hospitals and other medical facilities of

the Army had their hands too full with their own problems to have much time for civilians, either allied or enemy.

The understaffed, undersupplied G5 eventually turned over its medical headaches to the Surgeon. Now the medical department could support us and extend some of its seemingly limitless supplies of equipment and personnel to our problems. No one knew definitely "under" whom our team operated—G5 or the Surgeon—so we reported as the spirit moved us and where we thought we could get the most effective action. This loose arrangement had several merits: it allowed most lenient movement and definition of our own problems without too much regard for official channels; and we wrote our own Standard Operational Procedures as we went along. Every morning and evening we visited both G5 and the Surgeon, with the query, "Any problems today?" There always were.

The evening of May 3 we returned to Headquarters after an inspection of the large allied prisoners-of-war camp at Moosberg. Mike, our nearsighted driver, navigated our battle-reconditioned vehicle safely into the parking area once more. Outside Headquarters the sidewalk was crowded with liberated French prisoners waiting for the trucks that would take them to the next center on their journey home. We walked along the dusty cobblestone street past the row of Corps houses and neat little gardens surrounded by grilled iron fences. The invariable first item of business upon return to HQ was to ask for mail. Hop and I made for the house set aside for the Surgeon and his staff, and, since the mailroom never could decide whether we were with G5 or the Surgeon, Doris Gray, the UNRRA nurse, went to cover G5. She was in high favor with the German-accented sergeant who was the factotum of that office.

There had been considerable speculation about Doris when she arrived in the Army zone a few weeks before. Rumor had it that the red globe on her British cap was some sort of Soviet insigne and that the letters UNRRA on the red patch on her left shoulder were a capricious Russian way of writing USSR. Regardless of nationality and affiliation, however, she was a welcome addition to the Corps, especially since the Red Cross girls were usually relegated to Rear Headquarters. Aside from her professional aspects, she was most helpful when we had to deal with full colonels, supply sergeants, and other absolute authorities who were susceptible to the charms of a feminine smile.

Lieutenant Colonel Edward J. Vandercar, chief of the preventive medical section, was our liaison with the Surgeon's office. When we came in Van was carefully polishing a six-inch Luger, his prize souvenir and the envy of the Headquarters staff. He heard our brief report on Moosberg, put away his Luger, and led us to a map. "Tomorrow you better get over to Ampfing," he said. "Reports from Fourteenth Armored say there is a camp there that is worse than Buchenwald."

I dismissed that as an exaggeration. I had been at Buchenwald concentration camp three weeks before, and its incinerators, torture chambers, tanned human skin for lampshades, emaciated corpses piled like cordwood, and the starved, diseased, still living specimens of human degradation were fresh in my memory.

We located Ampfing just west of Mühldorf and traced the thin curve of road leading east from Denting. Then we all walked over to the mess with Van. The mess was on the first floor of the hotel in which we were quartered along with French liaison officers, visiting firemen below the dignity of being entertained by the General, and other personnel that attached itself loosely to the Corps. The

hotel had been cleared of its German residents, but they were always coming back to get potatoes and other food they had secreted under the beds and bureaus.

THE next morning, the four of us started out early in a car loaded with DDT, a few K-rations, a map, and ten hand-operated powder guns. Our military appearance was appreciably reduced by a total lack of weapons and the presence of a nurse who doggedly continued to wear skirts and who did not possess a helmet. I carried a silly leather riding crop inherited from a Nazi bigwig. Its snap had a salutary effect on the reactions of Germans and improved their comprehension of my hundred-word German vocabulary. Hop carried nothing but a notebook. Mike was the only one who had a frayed, dirty red cross on his left sleeve to denote our noncombatant status.

It was a beautiful spring morning; the ground mist was lifting, and the snow-capped Alps were dimly visible on our right. By nine o'clock we were in Ampfing. The war had passed over Ampfing without leaving its usual ugly imprints. Even the warehouses beside the small railroad station appeared intact. Such structures nearly always had gaping holes from artillery fire or showed evidence of looting. We were constantly on the lookout for large buildings that could serve as centers for displaced persons, but there were none in Ampfing.

We knew that there was no military government officer in the town, but it was always possible that some tactical unit had set up an office to act in this capacity. Our battalion and company commanders thought it was interesting work, and it made impressive reading back home when you could tell the folks you were now mayor of a town. The offices would abruptly terminate their functions, however, when hungry displaced persons, interrupted public utilities, and sick and demoralized Germans revealed other, less pleasant, aspects of civil administration during war.

We pulled up to the first intelligent-looking civilian. "Come here!" I growled. He came up to the car; if he was apprehensive he certainly did not show it. I asked him where *Militaerregierung* was and what about the *Bürgermeister*. The German did not know about military government, but the baker was the mayor. He waved his arms to indicate the directions. I asked him where the camps were, labor camps, concentration camps. "In the woods," said the German, "by the factories, all around." Attempts to elicit more specific information with my vocabulary were fruitless.

"O.K., Mike," I said, "let's find the bakery." Following directions, we soon came to it. Outside stood a man in a dirty gray, black-striped suit, the familiar uniform of the concentration camps. Another man in similar dress emerged from the bakery, his arms loaded with large loaves of bread which he dumped into the horse-drawn wagon that was standing by the door.

"Hey, Comrade!" I shouted, using the term that concentration camp inmates universally applied to one another. Both men turned sharply and with one motion jerked their caps off their shaved heads. They stood at attention, stupid smiles on their blank faces. I beckoned them forward and with gestures told them to replace their caps, emphasizing that they need not do that any more, ever. The smaller of the two was summoning up his courage. His lips moved, and on the third attempt he said, "I speak English, sir. May I assist?" The accent was French.

"Show us where the camp is," I said. He crouched on the fender. "Come in; sit down here," I said, pulling him up by his arms. He looked at me with

unbelieving eyes and sat down on the edge of the leather seat. "You tell the driver how to get there." The man jumped off the seat and crouched behind Mike. It was not until much later that I persuaded him to sit with me again.

We started to question him. How many people were there at the camp? About six hundred, but most of them had fled. What were the conditions? Bad, very bad. Any Americans at the camp? No, but an American officer had been there and said there would be help. He drew out a dirty slip of paper. "This authorizes the bearer to draw all necessary supplies for his camp," it read. The signature and serial number were illegible, a normal precaution when handing out such vouchers. Bread—he was getting bread for the camp. Was there any water or electricity at the camp, Hop wanted to know. No, nothing; electricity failed three days ago. Many people dying? Oh, yes, just about the usual number.

I asked our guide his name. "Andre Israel—French," he said and pulled up his sleeve to reveal a tattooed number on his left forearm. This was a camp for Jews, almost all Hungarians. He himself had been there six months and had been appointed a clerk because he spoke German. Was it an extermination camp, gas and incinerator chambers in it? Andre shook his head without changing expression. This camp was established only eight months ago. It was chiefly a stopping point for people who were on their way to Auschwitz (now again called by its Polish name, Oswiecim) where the gas chambers were—for two, or three, or perhaps four million men and women and children. Thousands had passed through here. Andre shrugged his shoulders, and his voice, dulled of all feeling, sounded as if he were talking about sides of beef. Then, two, three months ago, he went on, transportation broke down. They had buried over two thousand since then. Any other camps around here? Yes, about ten, but most of them were labor camps of the Organization Todt. There were two factories, one making explosives, the other cement.

We entered a wood. As in all German forests, the trees were carefully spaced, and the ground was clear of underbrush. A small metal sign on a post read "KL"—*Konzentration Lager*. We drove on. Around a sudden bend in the road, a fifteen-foot, triple barbed-wire enclosure loomed into view. At the top of each corner was a guardhouse equipped with searchlights. A few wooden barracks and several green silo-like structures were scattered under the trees. "Did anyone escape by climbing the trees?" I asked because some of the branches extended over the fence. "Escape?" Andre asked in bewilderment. "To where?"

The area was deserted and silent, and the cry of a bird echoed sharply. Without the barbed wire it would have seemed an idyllic spot for a vacation. Across the road were neat wooden houses, surrounded by a barbed-wire fence. "The guards lived here," said Andre. I felt a rush of anger, remembering Buchenwald. "Did the comrades get many of them?" Andre shrugged his shoulders again, a motion combining ignorance with the feeling that it was of no importance. "They got out fast. Had time to kill only a few comrades, maybe twenty, before they left. Perhaps some are still in the forest."

We stopped, and Andre jumped out of the car, ran to the gate, and shouted some names. Two men came running out of the nearest wooden barrack and drew open the gate. They stood stiffly, caps in hand, as we drove in.

"Who is in charge here?" I asked as we entered the largest barrack. We went into a dispensary, containing a wooden examination table, a few rusty

instruments, a row of ointment jars on a shelf, and a large poster on the wall announcing the louse as an enemy that must be eradicated. "Who is in charge?" I repeated. Andre translated.

"This is one of the doctors," said Andre. A tall, stooped man with an indescribably sad face, his metal-rimmed spectacles hanging loosely on his large nose, stepped forward from the door. "Doctor," I said, "how many sick people do you have here? Can you give me a list? And how many of them need immediate hospitalization?"

"All are sick," replied the doctor through Andre. "Hundred, two hundred. All should be hospitalized."

We asked about food. The cook had a few supplies left, mostly potatoes, and more were on the way. Enough for two or three meals; that is, for a cup of soup for every man. "Do you have any women or children in the camp?" I asked. Yes, there was one.

We were led to the adjoining room. A young woman was arranging a tattered blanket around an infant lying in a wooden crate. "A month old tomorrow," said the doctor. "The first one here who has ever survived that long." The mother and child appeared to be well, and the baby was being breast-fed.

"Surgical cases in here," said the doctor, opening the door to the large room occupying the remainder of the barrack. Here on double-deck wooden beds—mere wooden slabs covered with filthy straw—were gaunt shadows of men with shaved heads, showing their ulcerated legs, the unhealed whiplashes across their backs. They all had pale faces and puffy ankles, the protein-deficient flesh that was unable to recuperate from even minor wounds. Numbers were tattooed on their forearms or across their chests. What infectious diseases do you have here? we asked. Typhus. Are you sure it is spotted typhus and not intestinal typhoid? No way to be sure; probably both. No one with high fever in this ward.

We asked to be shown around, the worst places first, and went out of the barrack. On the ground by the door was a thickset man on his knees, hands folded in prayer, eyes shut. The doctor made rotary motions at his temple. "Crazy," he said. "A Pole, the only one we have here." Mike was breaking open a K-ration box and passing out its contents to two other inmates who had appeared.

Reinforced by four men who clambered onto the running board, we got into the car again. Andre was now more self-possessed and directed Mike through the muddy court. We bumped along between tree stumps and mudholes. "Here," said the doctor. In front of us was a raised knoll with a stovepipe sticking out of the ground. "Bunker," said the doctor.

We made our way on foot through an inch of mud to a hole in the ground. Crude wooden steps led down some eight feet. They were slippery, and our noses were assailed by a fetid smell combining decay, excrement, and sweat. "*Achtung!*" cried a voice. There was a moment of silence, and then a hoarse roar arose, an inhuman, unearthly sound. "America — hooray — hooray —" A dead, muffled, hopeless sound. "*Achtung!*" cried a voice again, louder. "No, no," I snapped. "No more! At ease!"

On both sides of a rectangular space were triple shelves, bare wooden planks. In the center, three wooden poles supported the ceiling. At the far end a nude skeleton sat on a barrel with a plank across it. He was supported by another skeleton who was standing; rather, they leaned against each other in order not to fall down. Bloody excrement was spattered around the barrel. We walked along the planks on the muddy floor. The shelves were filled with what had been men. Their bodies

were naked or only partly covered by a scrap of tattered, dirty, gray blanket. Their bodies were no more than skin stretched over bone; their knees were the thickest portion of their legs. Their shaved heads hung limply, eyes staring out of hollow sockets, noses abnormally prominent against the fleshless faces. Mouths were open, dry, red. Expressionless, animal-like creatures, they all looked alike; all individuality had long ago been washed out. Some had enough strength to turn their heads and followed us with burning eyes; a few turned over and extended their hands in our direction; some just lay, staring with unseeing eyes and barely breathing.

A soft, deep groan, a murmur of death issued from one of the bodies. "*Wasser, Wasser, bitte,*" the boy whispered. I felt his head; it was burning hot. A man who was standing stiffly at attention at the table in the center, a crude metal pitcher in his hand, did not move. He was the only one with clothes on.

What was there to say? "We shall help," I croaked. "We shall help as soon as we can." The tension broke. There was the inhuman whine once more, "*Hilfe, hilfe—*"

I turned around and made my way to the stairs. I found a look of ill-disguised nausea, disbelief, and anger on the faces of Doris and Hop, the same expression that must have been on mine. Mike stood on the steps, rigid and with a quivering lip; he looked at me with compressed mouth and swore.

We entered four more bunkers and two corrugated iron shacks. The shelf beds were arranged a bit differently, and one iron shack had one thin blanket per man. Some of the men were not quite so emaciated; others had great sores on their legs and backs. A few that stirred around, stumbling between the central table and the bunks, had ankles swollen with edema. It was more and more of the same. "We shall help, we shall help as soon as possible." If there was hope in their replies, I could not detect it, but none complained.

"How many of these men?" I asked the doctor, waving my arm to encompass the area. He passed his hand over his forehead and adjusted his glasses. "It is hard to think," he muttered. He turned to a comrade. "Get every bunker to count the patients at once!" He spoke in loud, harsh tones. He did not mean to be cruel, but it was the only way to get a response from these beaten, dulled people.

Hop pointed to one of the half-dozen silo-like structures, each perhaps twenty feet in diameter, covered with a thatched roof. "What are those?" We were led to one by Andre. A small door, no windows, straw covering the floor. "The healthy ones slept in here," said our guide, "Fifty in each. Didn't stay healthy long. Some of us escaped the guards when they left by hiding in the straw." "All empty now?" I asked. "Yes, all that could walk have left."

We held a hurried conference. The doctor came up with the information that there were about 150 men in the bunkers. I asked how many doctors there were among the inmates. "Eleven," he said in a flat voice. "At one time there were over seventy. Many of the eleven are sick themselves. I am sick—" His voice faltered. Andre continued, "Many lawyers, actors, doctors in here. Almost all Jewish, Hungarian. No other Jews left."

Immediate hospitalization was essential for all. We thought that at best no more than half the people could possibly survive. In large concentration camps such as Buchenwald, where twenty thousand inmates were discovered, whole evacuation hospitals had been sent in to take over the rescue work. The numbers here were too low for such action, and the delays would be too long. We decided that we could handle the

organization phase ourselves. Hop and Doris would stay at the camp, delouse the population, and get them ready to be moved. I would go back and arrange for hospitalization and ambulances.

Mike unpacked a box of DDT cans and our ten hand guns. These consisted of a tin can attached to a hand-operated pump. The DDT powder was placed in the can, and a group of likely-looking individuals of a camp to be deloused were instructed in the gun's use. Clothing was loosened, and two squirts of the gun were directed down the front of the neck, the back of the neck, up each sleeve, and down the trouser or shirt belt, fore and aft; cap or hair was also powdered. This method effectively controlled insect life, did not entail undressing, and could be done rapidly. It was the main means of combating typhus in Europe. For the naked inmates of this camp, it would be necessary to dust thoroughly both their bodies and their ragged blankets.

Hop asked the doctor if he was sure that 150 people were all he had. The doctor bobbed his head up and down as Hop slipped a couple of K-rations into his coat pocket. Another English-speaking man was found so that Andre could accompany me back to Ampfing.

The car had sunk down in the mud, and we had some trouble getting under way. Andre sat in front with Mike, shaking his head in refusal when I invited him to the back seat. I asked him about big buildings in the area. There was a labor office at Ampfing—the *Organisation Todt* Bureau—and a school at Mühldorf. He thought there was a hospital at Mühldorf, too. Did he know of any *Wehrmacht* food or supply depots in this area? No, he did not think there were any. What about clothing and beds? The school at Mühldorf had been converted into barracks and had plenty of good beds, but he did not know about clothes. Any water or electricity there? He did not know but he understood that the building had been hit by a bomb.

We returned to Ampfing and were directed to the O.T. Bureau. It was a one-story building of two wings leading from a central reception hall. The wings were divided into rooms filled with desks and other office furniture. There was only one flush toilet, but there were several hand sinks; a weak trickle of water came from the faucets. The electric current was off. An adjoining building had a large kitchen with wood-burning ranges and the inevitable 600-liter German soup kettles.

I was covering the buildings with rapid strides, mentally placing the patients, beds, and medical equipment. A German in the mustard-yellow uniform of the Todt labor corps attached himself to us, running ahead, opening doors. He opened his mouth several times to ask me something, thought better of it, and screwed up his face in a quizzical expression.

The O.T. building was suitable and could house 150 people with some crowding. I turned to the German. "Are you in charge here?" I barked, and Andre translated. "Good. Then in two hours I want every piece of furniture out of this building and all the rooms swept and clean. Leave only the beds, if you have any, and one chair in each room. I shall order the mayor to furnish help, but it is your responsibility." The German snapped to attention and began to speak rapidly to Andre. "He wants to know if he can stay here. He has one small room." "Tell him we are bringing typhus patients in here and to get out in two hours but only after the work is done." The German's face responded to the word *Fleksfeber* (typhus), and he did an about-face.

Mike drove back to the bakery and we entered its warm, yeasty atmosphere. An ample woman met us, wiping her hands on an apron. I demanded the

mayor, and he emerged from a back room. "All right," I said, backing him up against the wall, "now listen. Get fifty strong people, anybody, and get them to work at once. You know the O.T. Bureau? Good. Clean it up, all furniture out. We are bringing concentration camp people in there, typhus, starved. Get fifty women and have each one bring a pail of hot water, soap, washcloths, and towels. These women are to wash up the poor people. Get food: chicken or meat broth, mashed potatoes, little bread, enough for 150 people. The women are to prepare 150 meals in the kitchen. Have them bring cups, plates, knives, forks, and spoons. All this must be done by two o'clock, three hours from now."

The mayor looked a bit dazed and counted on his fingers. "Fifty people, food for 150, soap, towels—what are we to do with the furniture?"

"Throw it out of the windows, anything. There is a court in back of the building. Stack it up there. I want it neat. You know the penalty if all this is not done?" The baker gulped and tugged at his collar. "It is hard, very hard." I looked as ferocious as I could and snapped my riding crop against my shoe. "At once!" The mayor edged himself away from the wall and ran out of the door. I could hear his voice summoning someone.

"Now," I said to Andre, "are you sure about those beds?" "Oh, yes," said my guide, "unless they have been destroyed." "You stay here and keep the mayor on his toes—you understand, see that he does everything that I ordered. I'm going for ambulances; and trucks to get those beds. I'll be back in about two hours." I had my fingers crossed at this point.

Back in Dorfen I gave Van a summary of our findings. "We need a medical unit in there, ambulances, and hospital rations." Van thought for a moment. "Blood plasma," he said, "vitamins—" "Food and care," I said. "And every hour means literally another life."

Van picked up the telephone. "How many ambulances can you get along with?" he asked. "About a half dozen, and a couple of trucks." I was using estimates that were a carry-over from the early, skimpy G5 days. Van reached the 187th Medical Battalion and in less than twenty minutes arranged for a platoon of the 662nd Clearing Company to take over the treatment of the concentration camp patients; seven ambulances and two trucks; rations and medical supplies. This was almost too good to be true.

In less than an hour Mike and I were out on the highway where the medical battalion was bivouacked; ambulances and trucks were lined up in readiness on the field. I outlined my plan to the officer in charge. We would return to Ampfing, I would proceed to Mühldorf with the trucks to pick up the beds, and the ambulances and a guide would start for the camp a half hour later. Several trips would be required to evacuate all the people. The medical platoon would arrange reception at Ampfing.

When we returned the O.T. Bureau was a beehive of activity. Most of the furniture had been stacked up in the court, and numerous papers, forms, and books were lying around in the halls. I could almost hear the yelps of complaint from some intelligence officer as he surveyed the damaged records, many of which were already burning merrily in the court; I ordered the rest deposited in a room over the kitchen. Women were scrubbing floors, and children were running about. Some American soldiers had drifted in, adding to the confusion, and the mayor came running, asking what the time was. I ordered everyone out but the actual workers. The kitchen

was also buzzing with activity. Kettles were steaming, and all the utensils were sparkling bright. Cups, plates, and the cutlery were in neat array on the tables. Andre and his friend from the bakery were sitting in one corner, munching huge crusts of bread.

"You think we could stay here, sir?" Andre asked, "There are rooms above the kitchen—" "Sure," I said, "you'll be needed. But now let's get those beds. And your friend can show the ambulances the way to the camp."

We drove off, the two trucks following. On the right was a bluff with a cathedral and some large buildings overlooking the river. "Ecksberg Convent," said Andre. I filed the information in my head. We were not supposed to disturb religious installations, but often the Germans had already converted them to other purposes, and it was then assumed that their use was not prohibited. Mühldorf appeared suddenly as we emerged on the other side of a bridge. The north section of the town was badly beaten up. The streets were empty, but as we drove along, people began to come out, and suddenly the streets were filled. The town was still under daylight curfew.

I told Mike to stop, and Andre called out to the Germans to assemble. They came forward hesitatingly. Andre translated that I wanted ten men to climb up on the trucks to help me load things for about a half hour. There were no volunteers, so I pointed to the huskiest specimens and ordered them on the trucks. None was below forty years of age. The towns of Germany had long since been drained of younger manpower.

The school was a few blocks to the right and consisted of two stone buildings. One had been converted into barracks, and a gaping hole in the roof showed where a bomb had penetrated three stories of the building. It must have been a faulty explosive because the walls were still standing. Rain had increased the damage, and much of the plaster was on the floor or ready to drop. The place was filled with cumbersome double-decker wooden beds with gunny sacks stuffed with straw as bedding. A few of these beds would fill our trucks, and not many of our patients would be able to climb to the upper decks. The straw-filled bags, however, would serve as mattresses. I ordered 160 of them to be loaded and told the drivers to see that only clean, untorn ones were taken. The Germans went to work.

I decided to explore the other building. The door was unlocked, and Andre and I entered a number of schoolrooms, with desks, blackboards, and other paraphernalia. Behind the teachers' desks were Nazi flags and pictures of Hitler. On the second floor was an office and a small apartment. The bed had been occupied recently, and butts of American cigarettes were scattered on the floor. Some of the butts were stained with lipstick. A civilian suit was hanging on a hook. "Why don't you put this on and discard your outfit?" I asked Andre. He looked at the suit and tried on the coat. "If you don't mind, Major, if you please," he said, "may I keep my clothes? This coat is warm and I could use it, though." The concentration camp uniform had become a badge of honor and survival and was usually retained by the liberated inmates as they wandered over the roads of Germany.

The trucks were now loaded with the straw mattresses, and I dismissed the sweating Germans. We headed back to Ampfing.

The ambulances had already left. "Mike," I said, "you get yourself a handful of Germans and get these mattresses into the hospital. You'll have to put five or six in each room—and see that the rooms are clean" Mike jumped to his task.

Trucks and jeeps began to draw up at the gate. The personnel of the medical platoon selected one room for treatment and dressings, another one for an office, and began to unload their medical supplies. It was certainly not what a hospital should have been, but it was the best we could do

The work was not completed before the ambulances returned. The faces of the drivers were grim. As the first few stretchers appeared, some passing American soldiers and Germans stopped and watched silently from a distance. Only a few of the patients were on stretchers; the rest had been packed in sitting, eight to each ambulance. They began to come out. Men without clothing, without hair, without flesh, sores on their legs, their knees larger in girth than their thighs, a filthy piece of blanket around their groins. They stumbled and fell as they tried to navigate the three steps into the place before someone could help them. They shuffled a few steps forward and rested, exhausted, and looked around in wonder. A gasp came from the onlookers. The Americans swore.

The German women wrung their hands. "*Mein Gott, Mein Gott!*" they moaned, and it was not an act. Two women who had been cleaning up the hall stood transfixed. "How can it be?" they cried and dropped their brooms to help a stumbling Jew. Mike rushed forward. "Hitler's work. You ought to be proud of it!" he yelled at the women in English. I told him to help place the patients.

The macabre procession continued. It included some men in relatively better condition, dressed in striped suits, who introduced themselves as doctors. Doris emerged from the last ambulance. "We miscounted," she said. "They thought we meant just what they call the hospital camp. In the next compound there are about as many, although not as bad as these." I told the sergeant in charge of the ambulance crew to inform Colonel Hopkins that no more than 150 could be accommodated here and that we would have to leave the rest until new facilities could be established. The cook and half of the doctors were to be left at the camp, along with all available food.

"And I have brought the woman with the child," said Doris. I caught sight of the mayor's coattails and yelled for him and for Andre. "See that woman?" I said, pointing to the ambulance by which she stood. "She is to be taken in by your best family in town. She will be given a room, clothing, and rations. A layette for the child. They will be your direct responsibility. And if they are not treated better than an *Obergruppenleiter*. . . ." I snapped my riding crop. The mayor wiped his brow. "Ya, ya," he said, "it will be done immediately." He ran down the steps, talked to the woman, pointed back at me, and they disappeared up the street.

A patient shuffled across the hall. Starvation and disease had washed out all individuality. This skeleton was tiny, a boy that could not have been over fifteen years old. He stumbled up to Doris, dropped on his knees, and grasped her hands. "*Danke, danke,*" he sobbed, kissing her hands. A medical corps man led him off.

Another stretcher was entering the door. The man on it was not breathing. A thin line of bloody saliva had dried around the drooping corner of his mouth; on his face was a look of peace and hope, set in death. "Where do you want the body?" asked the stretcher bearers. They put him against the wall in the hall and covered him with a blanket.

The hospital was now starting to function, and the medical platoon was taking over. A Hungarian doctor was directing cases with obvious fever to the isolation rooms; a clerk in a striped suit was attempting to get the names; the Ger-

man women without further direction, disbelief in their eyes, were starting to wash up the tortured bodies. Out of the kitchen other women were carrying big trays and caldrons of food. I stopped them. "A cup of soup, a spoon of mashed potatoes, a small slice of bread only," I said. These men needed fluid, glucose in their veins, more than anything else.

I went into the room set aside as the office. Andre and another comrade were arranging some papers. Andre had picked up a typewriter somewhere. "I have some records," he said, "the list of the guards. I tried to keep the names of the people in the camp, but that is incomplete. Mostly we had just numbers." I took the list of the guards and thumbed through the pages. Most of the names were Hungarian. "Good," I said, "I'll see that this gets into proper hands."

"This is my comrade," said Andre. "He would like to stay here, too." The man was very short and stocky; his face was chalky, his hair almost pure white. "I am from Budapest," he said slowly in German. "I am a writer, thirty years old. I thank you. My wife is in London. Is there any way of writing to her?" He looked up at me beseechingly and repeated his statement word for word in the same monotonous tone. "You will have to refer to the medical officer, the captain who will be in charge. Perhaps he will have something for you to do." Once more the man repeated his speech. I knew there was no way at the moment for the man to reach his wife. "Look," I said, "supposing you write a note, and I shall see what I can do. Perhaps the Red Cross—" The man felt on the table for a piece of paper, grabbed a pencil, and poised it over the sheet. He shook his head and suddenly started to cry. "I can't remember her name or her address. For two years all I have done is repeat her name and address and now I can't remember. Please wait, please—" I sat down to study the list of guards and waited. Finally I left him with his grief.

The ambulances were now pulling up at the gate with the second load of patients. Some soldiers wandered in and had to be cleared out. A chaplain ran up the steps. "What horror," he exclaimed, "how terrible! Major, how can you stand it? What can I do?" There was no obvious reply to all this, so I let him stand and look at the starved patients as they stumbled or were led through the hall. Finally he murmured something about starting religious services, and ran bouncingly down the steps.

Hop arrived with the last ambulance of the third trip. His clothes were chalky with DDT powder, his shoes were muddy, and his face lined with fatigue. It had been a hard decision to leave some of the people at the camp. The cook had complained that there was no discipline any more. There was enough food for another day or two, and Hop had arranged to have the delivery of water continued by horse-drawn tank. He inspected our improvised hospital and went out with Andre to see the mayor about restoring the water supply and the electricity.

Doris came running. "Those German women are going to kill them. Did you see what they were feeding them?" Instead of a little broth and potatoes, the women were ladling out heaps of mashed potatoes, huge pieces of boiled meat, and slices of gray bread at least two inches thick. When the plates could hold no more, they served them to the men who had been washed up or passed them to the clutching hands of naked men who had stumbled and shoved their way to the food. Those who could sit up or stand were gulping the food like ravenous beasts. And those too weak to stand or sit were being fed by spoon. It was

useless to intervene now; we would have a riot to quell. All I could do was to order the portions cut. I fully anticipated mortality from this unorthodox method of treating starvation. Next day, however, we learned that except for a few cases of vomiting no untoward effects had been noted.

There was little else for us to do. The medical platoon was now in charge. They had set up the treatment room and were starting to examine methodically each patient, to establish a diagnosis, and to start therapy. The administrative officer was making out his list of needed supplies, and the residence across the street was being converted into quarters for the staff. The moribund men had been started on intravenous glucose infusions.

We assembled the five concentration camp doctors who had come with the ambulances and introduced them to the officers of the medical platoon. The doctors were instructed to stay and to assist in all possible ways. I promised to keep headquarters stimulated on supplies and hospital rations. We shook hands all around; the doctors in the striped suits looked proud and determined.

Next day the change in the patients at Ampfing was almost unbelievable. The medical platoon had worked all night. All the cases had been seen, examined, and recorded, including twelve cases of presumptive typhus; sulfa and other drugs were controlling the diarrheas; and only one man had died. The pinched faces of the patients were relaxed, and many of the men were sitting up on their straw mattresses holding a piece of brown paper with granulated sugar on it. They had requested that this wonderful confection not be put on the cereal they had for breakfast and instead they were now eating it granule by granule. "The first in a year, the first in a year," they repeated, smacking their lips. German women were scrubbing the floor. One crouched in front of a patient who was describing his previous activities as a lawyer and lecturing on the sins of the Germans, waving a long finger under her nose.

Rumor from the usual unreliable sources now had it that the war would soon be over. The radio was full of news of German Army groups surrendering, of German units fleeing from the Russians, of more contacts between American and Russian armies, of advances, final thrusts. We were too busy to notice. During the following few days we evacuated another concentration camp, set up another hospital at the Ecksberg Convent, inspected the labor camps in the area, and reviewed the civilian medical facilities at Mühldorf.

On May 8 there were speeches and announcements. It was the official V–E Day, but in Dorfen it was just another day. Trucks rumbled over the dusty roads, soldiers stood their formations, displaced persons wandered through the streets, and German soldiers filled the POW enclosures to overflowing. The German civilians still looked dazed and servile.

It was not until Churchill's stentorian "Advance, Brittania!" came over the air that Public Health Team Number Two caught some of the spirit of the occasion; we toasted the victory with the last of our whiskey. Two slightly inebriated soldiers on the steps below were singing "White Christmas" to the accompaniment of a liberated accordian when we finally went to bed. Before I could go to sleep that night, I saw gaunt men in striped suits on the roads, in camps for displaced persons, slowly making their way home. But they had no home. The road for them had just begun.

CLIMATE AS A NATURAL RESOURCE

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THE climate is part of the natural endowment of a country. In some regions it imposes hardships on the inhabitants, in others it makes life easy. Designs of living adapted to the climate of each region are the results of the accumulated experience of generations. They find their foremost expression in clothing, housing, and agriculture.

At present the outdoor climate cannot be changed, except on the smallest scale. This is axiomatic, and hence life has to be a continuous compromise with the climatic environment. But only in the regions of extremes is climate an implacable foe; elsewhere it is a friendly element that requires only to be understood in order to become useful. A country as large as the United States harbors a great variety of climates. They constitute, if properly exploited, a very important natural resource.

In contrast to mineral resources, climate is inexhaustible. Year after year the single weather events follow each other in unending procession and collectively make up our climate. While the individual day-by-day weather conditions are proverbially fickle, the climate remains fairly constant, at least within a human lifetime. This fact makes it possible to treat climate as a calculable risk. Wherever climatic conditions are adequately known and described, they can be intelligently integrated into plans for all kinds of human activity.

Good administration of an estate starts with the knowledge of assets and liabilities; therefore a comprehensive inventory is the prerequisite for proper use of climate. In the United States the survey of the climate is one of the official functions of the U. S. Weather Bureau. A network of stations observing the weather daily and hourly, manned by professional observers, spreads all over the country. This network provides the necessary data for daily weather forecasts and for the protection of our airways. Climatic information is just a by-product of these activities.

Exclusively serving climatological needs are the data collected by over 4,000 voluntary observers. They constitute one of the least recognized yet one of the most important mainstays of the climatic service of the country. Without the readings taken faithfully every day for decades by these enthusiastic amateur weather observers, the nation would have a most incomplete knowledge of its climatic resources.

For special purposes, climatic stations are also maintained by organizations outside of the Weather Bureau; for example, the Army and Navy, the U. S. and State Forest Services, the Soil Conservation Service, the Bureau of Reclamation, the Tennessee Valley Authority, colleges and universities, agricultural experiment stations, and numerous private power companies. According to a rough estimate, climatological data are collected at about 8,000 localities throughout the country. Impressive as this figure may seem, there are still hundreds of square miles without even a single rain gauge. Moreover, most of the existing stations provide only readings of precipitation and temperature. Wind, humidity, evaporation, duration and intensity of radiant energy from sun and sky are regularly observed only at the main Weather Bureau stations. For many practical purposes an urgent need for more climatic stations still exists.

In spite of this inadequacy much can be done with the data now available, although a serious handicap is posed by the fact that there is no central depository for *all* climatic observations that are being collected. To the Weather Bureau flow regularly only the data from its own stations and cooperative observers. A most definite need exists for a comprehensive directory of all climatic stations in the country and a central archive for all current and past observations.

An even more serious deficiency is the lack of organic statistical treatment of the data. Many observations, after they have served the hour-by-hour needs of aviation and the day-by-day needs of the weather forecaster, are simply filed. They constitute only a *potential* source of further information. They should be summarized and analyzed. The latest publication of comparative summaries for rainfall and temperature observations at Weather Bureau stations dates back to 1930. Since that time up-to-date statistics of climatic series in published form have been available for only a little over 100 localities for each year. This is most regrettable because a census of climate is as valuable a source of information as a census of population. Industry, trade, and agriculture use the census figures published every ten years to great advantage. These same interests could derive as much benefit from regularly published climatological statistics.

Because many consider climatic data as rather intangible information, considerable reluctance exists to spend money on an analysis of what seems to be "past history." To this, one has to add criticism of the inefficient methods in handling the data, which in the past were mostly laboriously compiled by hand. This is a tedious process that consumes many hundred thousands of man-hours and often provides statistics that are not yet in a practically useful form. For years the employment of laborsaving and flexible machine methods of compiling these statistics has been advocated.

In that procedure each climatic observation is punched on a record card, and tabulating machines do the rest. Foreign governments such as those of Czechoslovakia, England, Germany, and Holland have long treated part or all of their climatic data in that fashion. In the United States before the war only a few limited compilations of that type were made as WPA projects. The exigencies of the big conflict saw some remarkable expansions in machine analysis of climatic data. Information on atmospheric conditions in all parts of the world was needed for purposes of military planning. The weather services of the armed forces jointly with the Weather Bureau embarked on an extensive punch-card program and established an archive of millions of observations, mostly from foreign regions. There are plans to keep punch-card records in the future for at least a small network of key stations in the United States. But for the vast store of data now buried in the files, covering at many places fifty or more years of observations, the modern methods of statistical treatment remain only a dream.

The question arises immediately: Are climatic data only useful enough during wars to warrant expenditures for efficient summarization? Is climate an important piece of intelligence only in the grim business of killing people in the most efficient manner? The answer is an emphatic *No!* Then why are the wartime experiences not translated on a large scale for peacetime purposes? The reason is that many have only the vaguest notions how climatic information could be used. We shall attempt to outline a few applications of climatic information to everyday problems.

Housing presents one of the most

pressing needs of the nation in the post-war era. It is quite obvious that we build houses to protect ourselves from the exigencies of climate. We build them to have a comfortable year-round habitat. We have a fairly good idea under what conditions we are comfortable indoors; for example, maintenance of a temperature reasonably close to 70° F. and a humidity of around 50 to 60 percent. Further, we want houses that are waterproof and able to withstand occasional gales; roofs strong enough to hold up under the maximal expected snow load; we want water pipes laid deep enough to prevent their freezing and storm sewers big enough to prevent flooding. In order to be able to put up a structure that will fulfill all these conditions we have to know as much as possible about the atmospheric conditions at the homesite. If climatic information is neglected we may build inadequately and will have to pay excessive amounts for maintenance or even face, at times, catastrophic damages. On the other hand, we may build an excessive factor of safety into the house and thus raise the initial cost of building. Either mistake is expensive and could be avoided by intelligent use of climatic information.

The available climatic observations are adequate to enable an experienced climatologist to answer most of the pertinent questions of architects and engineers. The most important gap in our knowledge is the lack of data on the intensity of solar radiation. Observations from about 20 poorly distributed stations in the United States are insufficient to evaluate the radiation factor as an additional source of heat for modern structures using new materials such as glass bricks. This calls for an expanded network of stations measuring solar intensities.

For estimating heating requirements of houses wind data are also of fundamental importance. At present, generally, temperature conditions alone enter into the basic design values of houses. Yet a very low temperature, say, 0° F. under calm conditions, will not require more heating of a house than the much higher temperature of 32° F. accompanied by a wind of 20 miles per hour. If frequency tables of winds associated with various temperatures were available, planning for heat requirements of houses could be materially improved. Closer cooperation between designers and climatologists in the future would undoubtedly result in better basic construction of homes.

Climatic data also ought to find more consideration in the erection of buildings for special purposes such as hospitals. Certain types of atmospheric environment are definitely undesirable for sick persons: prevalence of fog, lack of sunshine, strong winds, and wide ranges of temperature. In that respect it should be demanded that thorough climatic surveys precede the selection of hospital sites.

In the interest of national economy the use of climatic data for the planning of airports is also imperative. For the present, in spite of all the advances made in the use of modern electronic devices, safety and economy of aviation still depend on atmospheric conditions. The proper layout of runways is intimately related to the winds prevailing at the site for the airport and especially the relations of winds to blind flying conditions caused by low ceiling and poor visibility. If these factors are considered during construction, the runways can be built properly from the outset and later expensive corrections can be avoided.

When new airfields are planned a number of sites may be equally advantageous from the point of view of accessibility to cities, availability and suitability of land, drainage conditions, etc. The final choice among the alternatives should be made on the basis of climatic data. A

good airport ought to have the smallest possible number of climatic hazards. These may vary considerably even over a small area. Improper choice can make it more difficult to maintain regular schedules, and a site only a few miles away might be climatically vastly superior.

Also, in the routing of flights, due regard to regional climatology can lead to avoiding zones of cloud-shrouded mountains and their hazards as well as zones of habitual atmospheric turbulence with their ill effect on passenger comfort. Economic considerations, especially on long-distance flights, dictate the use of climatic data on upper winds for the planning of routes. This leads to reduced gas consumption and helps to maintain optimum flying hours.

Aviation and weather science have grown up together. Past experience shows that all those concerned with air traffic make large-scale use of information about the atmosphere. Unfortunately, there is much less liaison between other traffic interests and the sources of climatic information. However, national plans for the immediate future, especially in the field of highway construction, raise a good many problems related to climate. The ideal of the highway engineers is the "all-weather" highway, modeled after the pioneering prototype, the Pennsylvania Turnpike. In the mountains of the colder regions of the country the distribution of snowfall is one of the most important considerations in highway construction. From valley to valley that element varies considerably. Climatic data can outline the optimal conditions for such "all-weather" highways. In addition, important basic data for proper drainage and bridge construction can be made available to the highway engineer. The proper appraisal of climatic factors in highway construction can save millions of dollars annually in maintenance expenses.

We need to place little emphasis on the use of climatic data in connection with dam construction and flood control measures. Sad experience has taught the responsible agencies the value of this information. This cooperation has been mutually beneficial for the engineers and the climatologists because it has led to the establishment of many new climatic stations and snow survey courses in mountainous regions where the climatic network had been inadequate. The limit of the desirable has not yet been reached because beyond the problems of flood control water supply questions are of vital interest in some parts of the country. In the arid and semiarid regions irrigation for agricultural purposes sets off thriving areas from desolate desert. The available water supply from precipitation governs the size of the area that can be adequately irrigated, and, while reservoirs equalize to some extent the variations from season to season and year to year, the basic plan for irrigation projects has to be predicated upon the normal climatic pattern.

In the over-all picture of national economy the planned use of water resources is still lagging far behind the possibilities. It is one of the few fields where engineering can contribute toward an amelioration of local climatic conditions. The planned use of rainfall also constitutes living on the annual "income" rather than tapping the capital—that is, the often irreplacable resources of lake and ground-water supplies.

The exploitation of climatic "income" has also spread in another direction. We refer to the use of wind for power production. Of course there is nothing new about this. In the windswept areas of Holland windmills have for centuries added their picturesque silhouettes to the landscape. Farmers in this country too, in the days before rural electrification became a reality, used wind motors for pumping water. But only in the past

decade have schemes for commercial power production by wind engaged the planners of public utilities. Such projects present difficult engineering problems. The wind at most localities is quite variable in direction and intensity. Economical power production, however, is based on maintaining proper levels for the fluctuating load requirements. To adjust the variable wind to the variable load is so complicated that many engineers have rejected the scheme as impractical. Some localities, however, offer very attractive opportunities. This is proved by the experimental installations of some power companies in New England where extensive preliminary climatic investigations were conducted.

Even in the coming age of atomic power it will be necessary for mankind to look toward living on an inexhaustible "income" rather than on the valuable "capital" of limited mineral resources. The use of such "climatic income" as wind, rainfall, and solar radiation warrants much larger initial investments because the requirements for recurrent expenditures for supplies will be much lower than in conventional engineering plants.

In terms of long-range planning agriculture is likely to be the branch of the national economy that can make the most profitable use of climatological information. The majority of crop plants are sensitive to climatic conditions. Selective breeding has extended the limits within which certain plants will be able to exist, but yields still are mainly subject to climatic factors. In a country where a surplus of many crops is produced climate-resistant plants are much less essential than in countries with marginal agricultural opportunities. In the United States with her variety of climates nearly all essential crops can be grown domestically with the exception of certain strictly tropical products. The problem, therefore, is not one of obtaining a crop but one of the most effective land utilization, that is, of raising profitable crops instead of overproduction of certain staples. And this question of substitute crops is largely one of a climatological nature.

Equally important for the national economy is the question of climatic risks in agriculture. It is an inherent attribute of climate that it includes all the atmospheric variations taking place over a period of time. That means the year-to-year fluctuations of temperature, rainfall, and other climatic elements are part of the over-all climatic picture. It often happens that during an individual year lack of rainfall leads to serious crop failures in an area otherwise well suited for the particular type of crop. On the other hand, in a year with rainfall much above the normal certain crops can be grown in regions where the usual atmospheric conditions are adverse. These exceptional conditions may persist for several years in succession. In the past, transitory improvement in weather conditions has led to agricultural expansion into submarginal regions, but initial successes were followed by disastrous failures when the climatic factors swung back to normal or to the opposite extreme. Seasonal weather forecasts may perhaps one day permit anticipation of such conditions. Then, and only then, can the farmer safely utilize submarginal areas in good years and refrain from planting in years of anticipated poor conditions. At present we are still a long distance from this goal. In the meantime climatic records offer the only reliable guide.

The climatic stations with a long record reveal how many years in the past were good and how many were poor for a given crop. There is no scientific reason to believe that our climate will change radically in the next few decades; hence we can safely accept the past performance as an adequate guide for the

future. Good and poor years will occur with approximately the same frequency as heretofore.

The ideal is to raise various types of crops in the most favorable climatic environment with the least risk over longer periods of time. This can be achieved if climate is incorporated into agricultural planning, on the basis of actuarial appraisal, on an equal footing with economical factors and considerations of soil conservation.

So FAR we have mainly dealt with necessities of life in terms of shelter, transportation, power, and food. To these we should add recreation as an important balancing element in our lives. The attention of the climatologist in that respect will be focused on problems of resort climate. It is the question of *when* to go *where* for your vacation. Special interests have overadvertised the climatic advantages of certain regions of the country, but elsewhere the climate has not yet been recognized as a valuable source of revenue from tourists.

A country-wide appraisal of the various climates for recreation purposes, by objective evaluation of the facts, has yet to be made. European resorts have studied this factor for years. A whole science, which is a branch of balneology, is built around the study of effective use of the climatic environment for the healing of disease and the relaxation of vacationists. The benefits and contraindications of various climates have been investigated. Climates beneficial for respiratory diseases, nervous disorders, and circulatory troubles have been determined. There were times in the past when it was fashionable for people seeking relief from chronic illness to go to Europe for cures. Fortunately for the multitude that cannot afford such trips, the North American area offers in fact a wider variety of climates than Europe. There are localities in this country which have climates comparable to those of the most famous resorts in Switzerland or on the Riviera. In many cases the only difference is that nobody has written learned papers about those located in the United States. In the interest of the health of those needing climatic therapy the opportunities offered by our domestic climates should be exploited. If climatologists and physicians would cooperate to make use of the available climatic information for this purpose a great deal of suffering could be alleviated.

For the others who enjoy unimpaired health we can use climatic facts to make their vacations more enjoyable. Tourist guides often contain nothing more about the climate than catch phrases. What is needed is factual material on local climatic conditions as related, for example, to clothing for various seasons. Many a trip could have been more enjoyable had the participants been properly prepared for the climatic conditions.

A few attempts to survey the climate for the purposes of recreation have been made, mainly in connection with winter sports. Maps showing the duration of snow covers in some of the prominent winter-sports resorts have been prepared and help to reduce the risk for the planning of contests. But in that respect, too, more remains to be done.

Let us say in conclusion that the unlimited climatic resources of the United States still await exploration and exploitation; they wait to be tapped. They promise full returns by better adjustment of our homes and health, our agriculture and technology, to the atmospheric environment.

DO YOU KNOW A DYSLEXIAC?

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THE judge of the Juvenile Court looked at Bobby, twelve years old, and wondered what made him such a rascal. The youngster had been hauled into court for attacking his bedridden father and playing truant from school. Rebellious and defiant, he was headed for trouble. The judge learned from the court psychologist that Bobby was suffering from dyslexia, an inability to learn to read by the usual methods. This handicap was at the bottom of his delinquency.

What puzzled the judge even more was the psychologist's report that the boy had good general intelligence. He was self-reliant, able to care for himself, and could size up a practical problem in a mature way. Just recently, without any money, he had traveled thirteen miles on his first subway ride to the zoo and returned home in time for supper. Later on he explained that he wanted to see some of the strange animals he had heard about; that they were more interesting than his class work. The reasoning was solid enough, particularly when the judge learned that for six years Bobby had been a member of the same "ungraded" class because he could not learn to read like other children. Quite understandably, he resented being associated with children much younger than himself and having to take the taunts of some of his neighbors. Bobby learned at a tender age the stigma society places upon the person who cannot read.

Somewhat more dramatic than the run-of-the-mill cases, Bobby's problem serves to illustrate the serious consequences often growing out of dyslexia. We live in a civilization based on speech, reading, and writing—a linguistic civilization, if you please. And those of us handicapped in the use of these indispensable tools of civilized man have a hard time of it.

Bobby's experience also illustrates how the removal of a handicap can result in complete rehabilitation of the personality. For, once the boy's difficulty was identified and analyzed and he was given specialized training, he learned to read and to take his rightful, happy place among boys and girls of his own age.

How many people with dyslexia there are in and out of the schools no one knows, but the indications are that they exceed the total of the blind, the deaf, and the insane. From Pearl Harbor until V–J Day more than 1,000,000 draftees were rejected or specially classified because of dyslexia. Yet the vast majority of these men attended school through the sixth grade, and less than 7 percent had low-grade intelligence.

Reading surveys conducted in the schools here and there indicate that from 8 to 25 percent of all children have reading disabilities. On the whole, these children are not deficient in intelligence. Another arresting fact is that males usually outnumber females in reading disabilities, the ratio being approximately 4 to 1. In all linguistic functions the female sex is more gifted, for girls talk earlier than boys; they have fewer speech disorders, such as stuttering, where the ratio is about 7 to 1, and they have larger vocabularies.

Almost all reading disability cases in the schools are identified as *developmental dyslexia* because they have no back-

ground of serious illness or head injuries. These children ordinarily "see" all right, but they confuse similarly shaped letters like *o, e, c* or *b, h, n.* Or they substitute words like *old* and *cold, eat* and *meat.* Sometimes words are read as mirror images. Spelling ability is also affected, and eye strain is a frequent complaint among them. They often lack precision in recognizing complex patterns or fail to react to words as units but spell them out in a fumbling, trial-and-error sort of way.

As a group their immediate auditory memory span is short, and many of these children have speech defects. Stuttering, for example, is about eight times more prevalent among dyslexiacs; and articulatory disorders such as lisping and infantile speech, about twice as common. There seems to be some connection between certain speech defects and dyslexia. That is why psychologists favor delaying the teaching of reading until the youngster develops fluency of speech and listening discernment, even though not all children with mutilated speech are necessarily dyslexic.

The description and diagnosis of developmental dyslexia is guided by our knowledge of what constitutes efficient silent reading. The good reader finds no difficulty in following horizontal lines from left to right, and his eye movements are *saccadic,* that is, they advance by spurts rather than travel smoothly. But what is equally important, his regressive eye movements are few. He recognizes words in a group, known as the *span of recognition.* Pauses are short between spans. This is significant when we recall Tinker's findings that 94 percent of all reading time is ordinarily devoted to pausing, or *perception time.*

The good reader holds the thought and does not make a habit of returning to the beginning of a unit he has already read. In the technical jargon, he has few *return sweeps.* Neither does the good reader mouth his words as he reads, for mouthing puts the brakes on speed; nor does he have poor binocular coordination. He does not reverse nor transpose letters or syllables, a phenomenon known as *strephosymbolia.*

Strephosymbolia, which literally means twisted symbols, is marked by *static reversals,* exemplified by the consistent substitution of *p* for *b,* etc.; or words like *pot* and *tip* are read in their mirrored form as *top* and *pit;* and there are *erratic reversals* in which a letter like *l* may sometimes be read as *k* and at other times as *h.*

In short, the good silent reader is a rapid reader; he understands what he reads; and he remembers what he reads as he goes along.

As EACH case of dyslexia is highly individualistic—bound up with the total personality—he should be studied as carefully as possible and a re-educational program built around his specific needs. A checkup on physical health is indicated first. This should include a basal metabolism test. Many young dyslexiacs have under- or overfunctioning thyroid glands, for example. The former is often responsible for sluggish attention and dull intelligence, and the latter is sometimes associated with hyperactivity and emotionality, a syndrome colloquially identified by some psychologists as *antis pantis* or even *termitus trouserus.*

The case of a boy nine years old is pertinent. Underweight, he suffered from insomnia and wide swings in mood. Sitting still was difficult. These basic difficulties had to be resolved before a detailed diagnosis of his reading disability could be undertaken and a re-educational program prescribed.

Because many of the current methods of teaching reading are kinesthetic, the study of the dyslexiac's motor coordina-

tions is helpful. Many dyslexiacs are unusually clumsy and fail to carry out ordinary skills in the use of the hands and eyes. That is why they are called *apraxic*. For them, motor retraining may be the first step in their reading rehabilitation.

Identification of the dyslexiac's preferential hand and eye may also reveal helpful information. While the subject of handedness pivots on conflicting points of view, many authorities agree that (1) a child should not be forced to write with his right hand when he prefers the left; and (2) when ambidexterity in writing exists, the child should be trained to use one hand, preferably the one on the side of the dominant eye. Instruments like the microscope, kaleidoscope, and manoptoscope can be used to determine eye dominance. In privileged communities, ophthalmographs and ophthalmic telebinoculars are available for photographing and studying movements of the eye during reading.

Dyslexiacs also need periodic examination for visual acuity and coordination. Corrective lenses and prism exercises are sometimes prescribed by the oculist for strengthening certain muscles and coordinations. Although lowered vision is not the usual cause of developmental dyslexia, instances of aniseikonia, nystagmus, myopia, and strabismus are not rare. Tests for Daltonism, or color blindness, should be given because many re-educative exercises are based on association of colors with words. If the dyslexiac is color blind he will not profit from such exercises; indeed, they may add to his confusion. Dyslexiacs in the schools should be provided with excellent lighting and front seats.

Audiometric examinations are also necessary and should be administered at least once a year. Approximately 1.5 percent of the entire school population in our country are hypacusic. While this group may hear many noises and some speech sounds—thus unknowingly disguising their aural losses—their hearing is dull enough to interfere with their learning and human relations. As many re-educational drills for dyslexiacs are based on phonics and phonetics, it is important that they should hear all the speech sounds, of which the American language contains approximately forty. A significant hearing loss may call for a mechanical or electrical hearing aid or lip-reading instruction before the dyslexia is attacked.

This brings up the subject of good speech as an invaluable asset in learning to read. As the spoken word is more basic than the written word and its interpretation—that is, reading—speech defects should be attended to as early as possible. In enlightened communities good speech habits are stressed throughout the grades and high school and particularly in the kindergarten and first grade, *before* children are taught to read. A child pronouncing *three* as *free* or *row* as *wow* or *sister* as *thithter* has a potential reading handicap.

Is the child ready to read? Think of three boys, all six years of age, with similar backgrounds and intelligence. One finds reading easy and enjoyable; the second learns with great difficulty and hates it; and the third does not learn to read at all. Some psychologists believe that if the second and third boys were not taught to read until they were eight years of age, they would learn to read more efficiently. In other words, there is such a thing as *reading readiness* just as there is speech readiness and walking readiness. That is, we differ one from the other in the time of life when our physiology and psychology are ready to adapt to various functions. If our schools would wait until the second or third grade to begin to teach reading,

we would undoubtedly have fewer dyslexiacs.

Dyslexiacs ordinarily have emotional maladjustments growing out of their reading disability. Children are especially great conformers to the standards of their group. If it is customary for youngsters attending a certain school to cover their textbooks with brown paper and one boy's mother covers his with oilcloth, he may be laughed at If the boys wear trousers, the newcomer who wears knee pants will be ridiculed. And so it is with a reading disability: the dyslexic child is made to feel "different" from his associates. Attitudes of inferiority and frustration become the building blocks for personality quirks that often persist long after the dyslexia has been corrected. A person who cannot believe what his eyes tell him lacks assurance every time he looks at the printed page.

Determining the dyslexiac's interests and hobbies ordinarily uncovers a good deal of matter on which to build reading interest. One boy of ten who had not yet learned to read was preoccupied with airplane models. The psychologist won his interest in reading with a copy of Jordanoff's illustrated *Aeronautical Dictionary*. Through the invention of word games involving airplane parts, meteorology, and allied subjects, the boy was soon taught to read. This kind of approach to the problem can be carried out at home too, with mother and father supplementing the psychologist's outline of procedure.

Once the reading disability is diagnosed, various methods are available for the re-educational program. By and large they are designed to strengthen visual learning by calling on the other senses as teachers. For example, before the child is given printed matter to study, he may get the "feel" of the alphabet by tracing six-inch letters on the blackboard; then on large pieces of tracing paper; finally, in hand-writing size. Lettering by hand is preferred to cursive writing because of its closer resemblance to printed characters. Sometimes he is asked to say the sound as he traces or prints the letter. Small children discover interests in words printed large on pictures. Word games are made of the picture cards. Some psychologists advocate mechanically controlled flash cards and the metronoscope for training eye movements and word recognition. Others find them creative of habits not always useful in learning to interpret the printed page. Here, too, the old adage holds: "What's one man's meat is another man's poison." Only by studying the individual dyslexiac and supplying him with those aids that satisfy his needs is an optimum of progress assured.

Printed materials should always be selected with due care to typography and pagination. We have found 24-point type, preferably in boldface, best for the majority of young children. We never use print smaller than 14 point for children under eleven years, at least in the beginning. Paper ought to be free of glare, margins should be wide, and indentions deep.

Some years ago The British Association for the Advancement of Science recommended a 100-millimeter line for children over eight years of age. Dearborne advocates a length of 85 millimeters, which is approximately 3.5 inches long. *Reader's Digest* columns are 2.25 inches wide, undoubtedly one of the reasons (unconscious) for its tremendous popularity. Spacing between letters should be at least .3 millimeter. Lighting, seating posture, and position of the reading matter are of basic importance also.

No CONSIDERATION, however, is more significant than strong *rapport* between

the dyslexiac and his psychologist or teacher. Rapport, which is a reciprocated feeling of respect, confidence, and even affection, is invariably at the bottom of sustained progress in reading rehabilitation just as it is in so many other human relations. Certainly rapport plays a stellar role these days in retraining the many new cases of *acquired dyslexia* growing out of the war.

Acquired dyslexia identifies those cases of reading disability that follow an injury to the brain. The person afflicted with acquired dyslexia ordinarily has learned to read and then, as the result of a brain lesion caused by head wound or brain tumor or arteriosclerosis, has lost the ability to read in whole or in part. Occasionally a symptom is *hemianopsia* in which one-half or a substantial part of the scanning vision is lost. Such an injury usually entails many other disturbances of the linguistic functions, as the following representative case history illustrates.

When asked questions such as "What is your name?," "Where do you live?," "How old are you?" this man, thirty-six years old, would answer with a neologism, "Senowin." After saying this he would point to his tongue, frown, and shake his head. The examiner interpreted all this to mean: "I'm in a bad way; I know what to say but can't say it." He was unable to say any words at all except two profanities and "One, two, three, four, five, six, eight, ten," invariably omitting "seven" and "nine" and never getting beyond "ten."

But when asked to carry out directions like "Close the door," "Raise your right hand," or "Point to your left foot," he would follow them quickly and correctly, thus indicating that he understood oral words. Moreover, he could write some simple words such as *Bob, street, in.* But polysyllabics like *Mississippi* or *gentleman* he would not even attempt, saying, "Senowin." On various occasions, when asked to write words like *saw, on, tab,* he wrote *was, no, bat.* Spelling gave him much difficulty also, whether written or recited.

Given a standardized reading achievement test of the third grade, he identified only an occasional word such as *dog* and *cat,* and these were sometimes read in mirrored images as *god* and *tac.* His dyslexia was characterized by (1) ignorance of almost all words and (2) reversal tendencies in reading the few that he could identify.

This case of acquired dyslexia and associated disorders is particularly interesting when reviewed against a background of widely held beliefs of the functions of the brain in relation to speech. The cerebrum, or large brain, which is divided into hemispheres, controls both the muscular activities and their coordination in speaking and reading as well as the capacity to understand the spoken and written word. Physiologists have known for a long time that the hemispheres govern opposite sides of the body. Many of them maintain that one hemisphere is ordinarily dominant—that is, it has a higher rate of metabolic action than its opposite—and that the dominant hemisphere is located on the side opposite the preferential hand. They also maintain that the centers controlling the various linguistic functions are in the dominant hemisphere. In the words of S. T. Orton, "One side of the brain is all-important in the language process and the other side either useless or unused." It is believed that through re-education those brains cells not destroyed or injured can take over the linguistic functions.

This theory is nicely illustrated by the case under discussion, for the man was reported to have had no speech or reading handicaps prior to the onset of a paralysis which occurred one day as he

was greasing his truck. Found groaning by a relative, he was taken to a hospital where he remained for six weeks. The paralysis, confined to the left side of the body, gradually disappeared so that by the time he left the hospital he had regained the use of the larger muscles, thus enabling him to walk and grasp. But from the onset of the paralysis until he began a re-educational reading and speech program he did not talk except for the words listed and the neologism. His relatives were in agreement that he had always been left handed. As he was paralyzed on the left side and was left handed, it was believed by the neurologist at the hospital that a thrombosis had struck the right hemisphere. If the thrombosis had affected the left hemisphere, the right side of the body would have been paralyzed without involving any dyslexia and related disorders of language, according to this theory. Through individualized training conducted daily over a period of thirty weeks, the man learned to speak and read well enough to return to his vocation of truck driver.

It is interesting to note that many head wounds did not, in the recent war, entail dyslexic symptoms, although according to available reports the large majority of veterans wounded on the side of the head opposite the preferential hand presented disorders of reading and speech, varying in extent from a passing confusion to total word blindness and mutism. Most authorities are in agreement that of all linguistic disorders those growing out of lesions on the big brain are as a group the most involved. Re-education in reading, writing, and speech in such cases requires sustained effort by experts working in close cooperation with neurologists. Even so, acquired dyslexia, like developmental dyslexia, is amenable to improvement or complete rehabilitation.

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SCIENCE AND THE PURSUIT OF VALUES

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It has now become quite evident that at least one effect of the atomic bomb was not clearly foreseen by those who were responsible for its use. The physical effect—the destruction of life and property—this was predicted with a fair measure of precision. The political effect—the problem of secrecy, with the ensuing diplomatic issues—this was, perhaps, vaguely anticipated. But the widespread interest on the part of literary men, scientists, philosophers, politicians, and educators in the broader problems of the freedom of research, the role of science in liberal education, the relations between the natural and the social sciences, and the still more inclusive problem of the general nature of science as an enterprise of the human spirit—this, I should suppose, could not have been anticipated by any of the experts who had advance knowledge of the world-shaking event.

The fact of such interest can, I think, hardly be doubted. Evidence abounds in the pulpit, in current periodicals and newspapers, and on the lecture platforms. Scientists, who have heretofore cautiously refrained from dabbling in such "extrascientific" problems, are venturing to address forums, literary guilds, and luncheon clubs on precisely these issues. Educators, either fearing that the demonstrated importance of science will result in a crowding of cultural subjects from the curriculum or welcoming the renewed emphasis on science as an opportunity to gain much needed governmental aid in support of local research, are examining graduation requirements and the aims of education with reference to the proper role of science in the training of the citizen. Politicians, knowing little of the method and spirit of science, are deliberating over possible restrictions on the freedom of research and of the dissemination of scientific information and may soon, if history is to be relied upon, initiate discussion as to the advisability of introducing a tax on atomic bombs as an unexpected and fruitful source of government revenue. Philosophers, always on the alert for the basic issues involved in any enterprise, are becoming increasingly distressed by the narrowness of the traditional scientific outlook and the unwillingness of the scientist to see his discipline in its broader social context.

The effect of this widespread discussion of the general nature of science on our understanding of science itself cannot yet be ascertained. There is too much diversity of outlook in the various approaches and too much conflict of opinion in the solutions offered. But it seems reasonable to conclude that the effort cannot be wholly wasted; in the long run science stands to profit by a renewed interest in its nature and role in contemporary civilization. While the general impression one draws from such discussion is essentially confused, since the terminology in which the debate is carried on is vague and ambiguous and the problems themselves are not too well understood, some progress is being made. Though the issues are not being met, they are being isolated and clarified. New relations are emerging as significant—science *and* politics, science *and* education, science *and* value, science *and* society—relations which are at least bringing into juxtaposition aspects or phases of our culture which we have been content, by a vicious abstraction, to

consider in complete isolation. More than this, attention is now being drawn to the fact that science is not merely the special sciences—physics, chemistry, biology—but a unified outlook and method common to all the special disciplines, a unique way of viewing the world and man, a significant enterprise of the human spirit. We are thus beginning to find ourselves, more than at any time in the past, in a position to gain a new perspective on science, to see it as something more than test tubes and ammeters, more even than scientific periodicals and treatises; to see it, in fact, as one of the most inclusive and characteristically human modes of reacting to the world about us.

Much of the current discussion is vitiated by a point of view which, although favored by tradition, is unfortunate for the adequate understanding of science. Science and value, it is claimed, are utterly incommensurable. Any interest which is scientific can have nothing to do with values, and any concern with values must lie outside the realm of science. Look, for example, at the scientist. He is the ideal exemplification of objectivity and unemotionality. Preferences and aversions, hopes and fears, likes and dislikes—which are the habitat of values—are foreign to him; he is coldly logical, justly disdainful of emotional claims, and continues doggedly at his task until observation is brought into agreement with prediction. The pursuit of values may be an important activity of the human spirit, but the pursuit of values is not science and is therefore not for the scientist. Values are private, personal, and subjective; truth is public, impersonal, and objective. Nothing is good or bad but thinking makes it so; beauty depends on taste; even God is required only when our feelings, and not our intellectual needs, demand satisfaction. Science will have none of this. Its seed is fact; its nourishment is careful observation and cautious reasoning; its flower is abstract truth, pure and undefiled.

The result of this outlook is a misunderstanding both of science and of those value pursuits to which it is opposed. Science, so conceived, becomes a value activity only in terms of context, only when placed in the social situation and examined with reference to the uses to which its results can be put in the problem of social control and social betterment. *Practical* science has to do with values; *pure* science does not. Practical science is, like art, religion, and morality, one of the "humanities"; pure science is not.

I shall attempt to show in what follows that science—pure science—is not fundamentally different from art, religion, and morality. It is, like these other activities, a characteristic mode of human behavior in which man sets up for himself a certain goal which he considers highly desirable and which he endeavors to achieve by appropriately selected techniques. In order to demonstrate this I shall try to show, first, what essentially is involved when one speaks of art, religion, and morality as value activities or value pursuits; second, what features exhibited by science afford ground for assigning to it a basic kinship with these other value disciplines; and, third, what consequences for our understanding of science ensue if we place it in this perspective.

IF, FOLLOWING Aristotle, we define man as a "rational animal," we run the risk of two serious errors. In the first place, man is not *merely* rational; he is religious, moral, aesthetic, and social as well. By emphasizing his rational capacities, therefore, we overlook entirely, or relegate to a secondary position, these other phases of his life which, for many, are dominant both in terms of the significance which they give to life and in terms of the actual portion of man's ex-

perience, quantitatively speaking, which he devotes to them. In the second place, to characterize man as essentially rational is to disregard the fact that men draw upon their rational faculties, except in rare cases, only for the purpose of achieving certain goals which are, if not irrational, at least nonrational. The desire to live well cannot be justified on rational grounds, nor can the desire even to live at all. It is in the realization of these ultrarational preferences that man needs the rational faculties as instruments.

It seems more accurate, therefore, to define man as a "valuational animal." By this is meant simply that he is a creature with likes and preferences on the one hand and dislikes and aversions on the other, who sets about by appropriately directed activities to maximize and render permanent the positive values and to eliminate, minimize, or render transitory the negative values. Many of these preferences and aversions are specific and temporary—as in the case of liking or disliking certain foods, certain modes of dress, certain types of amusement, certain types of people. But all such valuational attitudes can be grouped, in terms of the objects desired, into general classes which may be called the characteristically human and enduring appraisements. Among these basic objects of desire will be found health, recreational values, wealth, pleasure, love, goodness of character, piety or spirituality, and beauty. Around each of these values there gathers a cluster of activities and experiences which are united to one another by the common end. Morality, for example, is the sum total of activities performed by the individual and the sum total of experiences through which he passes in his attempt to achieve an ideal or standard of "right living." Art, similarly, is a name for those phases of human behavior and enjoyment which are concerned with the realization, either in the form of creation or in the form of appreciation, of the value of beauty. Religion—somewhat less adequately defined because of its complexity and because of the manifold forms under which it has appeared—is that aggregate of experiences, including prayer, worship, and meditation, which are directed to the realization of an attitude of spirituality or piety, which is a way of looking at the world designed to comfort man in times of sorrow, afford him something before which he may humble himself, and inspire him by virtue of its fundamental position in the universe to continue his struggle against the forces of evil.

Is there anything common to these various forms of value pursuit? It seems evident that however the values may differ there is the recognition in each case that the value in question is in some sense ultimately and finally desirable and worthy of attainment, even though such attainment involve the sacrificing of other values. To ask why one pursues the value is to ask an unanswerable question. The only reply—which is really not a reply at all—is to say that man is so constituted that he *does* esteem this particular thing highly and is willing to forsake some of the other treasures of life in order to get it within his grasp. Once the values have been selected, their achievement then becomes the directing factor in the life of the individual; henceforth he selects his activities, rationally or irrationally, with a view to their presumed efficacy in enabling him to realize the final values. In terms of these goals the activities and experiences prove satisfying or dissatisfying. Disappointment, despair, and frustration occur when progress toward the goal is too slow or when attainment of the value in question involves abandoning other values which are themselves desirable. Satisfaction, enjoyment, and a sense of well-being occur

when the choice of means proves to have been successful and when the individual is able to recognize that the goal, once remote, is now almost within his grasp.

We may conclude, then, that to be human means to pursue values. As a result of the diversity in our organisms and environments, the things which are valued are many and various. But they tend to fall into certain well-defined classes, which represent basic types of value preference. However diverse and specific may be the objects of men's desires, the things which they prefer ultimately and for which the more specific values are instruments or means prove to be surprisingly alike. These final values, then, may be taken as principles according to which we may break up his total experience into clusters of activities and enjoyments. Among such unified aggregates of experience we find art, religion, and morality.

Is SCIENCE essentially like art, religion, and morality, or does it differ fundamentally from these modes of value pursuit? Evidently the issue cannot be settled with any finality. Since any two things which are alike are also different in some respects, no complete identification of two things is ever possible. But by emphasizing similarities we may, and often do, gain an understanding which would have been impossible if we had attended merely to the differences. The question, then, is whether by considering science as a value pursuit we are not enabled to gain new insights into its nature, to understand it, that is, both in its essential character and in its relations to the broader context of experience in which it inevitably occurs.

At first glance the resemblance seems very striking. Science *is* the pursuit of a value—a value which is clear-cut and demanding. Whatever else science may be, it is an unusually persistent effort to achieve truth, wisdom, understanding, or knowledge. (For the purpose of this discussion these terms may be identified.) No one, I should suppose, would question the fact that the scientist desires these values in some significant sense above all other things. Whether they are in and of themselves desirable, or merely desired as instruments by which humanity may be bettered or life may be made more comfortable, is not relevant to the present issue. Evidently any one of the values of life may be desired as a means to the attainment of other values. But there must be at least one value which is preferred in and for itself. For the pure or theoretical scientist knowledge is an ultimate and final value; for the practical scientist or engineer knowledge has value as a tool which may then be employed to realize another value—say, better living—which then itself becomes an ultimate or final value. If we grant this it becomes clear that science is a broad and inclusive term covering all the activities—observing, experimenting, measuring, generalizing, forming hypotheses—and all the psychological experiences—excitement, interest, enthusiasm, as well as despair, discouragement, and frustration—through which the scientist as a human being passes in his attempt to realize the goal of adequate knowledge. We are so accustomed to thinking of science in terms of its results that we tend to overlook the fact that science is, properly speaking, *scientists*. Scientists are human beings like you and me who, unfortunately, suffer from dyspepsia, hate to pay their income taxes, and have family troubles but who, fortunately, enjoy the company of friends, take pleasure in a cigar, and like to go fishing. What is more important, the pleasures and displeasures which they experience in their scientific activities are of essentially the same kind as those which they enjoy and suffer as common men in the practical relations of life and society. Science is,

then, like art, religion, and morality, a complex of behavior adjustments and emotional reactions which derive their unity from the fact that they are selected, employed, and appraised by the individual in terms of their efficacy in enabling him to achieve a state in which he can be said to have satisfactory knowledge of the world about him.

Even more striking resemblances between science and the other forms of value activity appear as one penetrates beneath the surface. Characteristic among these is the feeling of "oughtness" which seems always to be present in the pursuit of any one of the major values. This feeling appears whenever the conflict between the *desired* and the *desirable* becomes dominant. To say that value is *desired* is, in a sense, to utter a truism; for if a thing is not desired then it is simply not a value for the individual concerned. But to say that a value is *desirable* is not to assert a mere platitude; for if a thing is *desirable* then it *ought to be desired,* and the plain fact of the matter is that we do not desire many things which we feel that we ought to desire. To decide between what we want and what we feel we ought to have—this represents one of the most pervasive and unsettling conflicts with which man is confronted. In the moral sphere the opposition is between pleasure and duty; in the sphere of art it is between what we personally and privately like and what the critic tells us we should enjoy; in the sphere of religion it is between the many temptations which life offers and our responsibilities to God.

Science, too, exhibits this conflict. In fact, the very presence of decisions of this kind in science has led many to believe that the scientist is not concerned with value. But the truth is that such a choice is a choice *between* values *within* science. The feeling of obligation is strong in science, and that which ought to be preferred usually wins over that which is preferred. It is this strong responsibility to an ideal that restrains a scientist from publishing before he is sure of his results but also impels him to publish them as soon as they have been checked; this same feeling tells him that the unfettered imagination, however inviting its products may be, has no place in science; that observations obtained under conditions of haste, excitement, or fatigue, however urgently they may have been needed at the moment, are thoroughly unreliable; that "pet" theories must be verified with extreme caution because of the emotional halo which surrounds them. None of these is a case of throwing value out of science; rather, certain values—those of objectivity in attitude and caution in method—are held to be dominant over those of emotionality, personal prejudice, haste, and carelessness. The scientist is not a logical machine; he is only a machine which automatically employs approved rather than disapproved techniques of thinking.

A third characteristic of value pursuits is the presence of qualitative distinctions between values—distinctions between higher and lower values. The classical illustration of this is to be found in the writings of John Stuart Mill, who, arguing against the earlier utilitarians and their insistence on the primacy of the principle of quantity as a basis for deciding between the desirability of competing pleasures, pointed out that on these grounds "pushpin would be as good as poetry." Since poetry, according to Mill, is obviously to be preferred to any simple game, the necessity arises for making a qualitative distinction between pleasures; poetry may not produce more pleasure than pushpin, but it produces a "better" pleasure. Whatever one may think of Mill's illustration and even though one may argue convincingly that pushpin *may* produce a higher quality pleasure

than does poetry, nevertheless qualitative distinctions between values *do* appear in all the value pursuits. In science the problem is illustrated by the difference between particular truths—"The mass of this piece of iron is 17.2 grams" or "This is an example of *Canis familiaris*"—and general truths or theories—Boyle's law or the evolutionary theory. Both types are truths and therefore fit into the general picture of science; but the latter seems to be on a higher level, to be more significantly involved in the forward movement of science. Thus there arises, at least in the minds of some, a distinction between the aristocrats of science who concern themselves with the "higher" truths—laws, basic presuppositions, integrating theories, and wide generalizations—and the plebeians in science who, at least in the eyes of the aristocrats, are mere fact-gatherers, gadgeteers, and pebble pickers. Whether the aristocrats and plebeians are properly identified here is not pertinent to the discussion. One might argue that since all theory must rest upon fact and there are clearly times when one fact is worth a hundred theories, those who are concerned with particular facts are the real aristocrats of science and the theoreticians are scientific philanderers and wastrels. The point is not whether particular facts are high-quality truths or low-quality, but whether the distinction applies at all to scientific truths. General truths are not more true than specific truths, nor is the reverse the case; both are truths, just as pushpin and poetry are pleasures, yet one seems preferable to the other on grounds of quality. That science does exhibit this distinction strengthens the reasons for a closer identification of science with the other value pursuits.

It appears, however, that there is one important difference between science and the other forms of value pursuit. Art, religion, and morality all seem to demand sooner or later in their development something which can be called *justification.* Art which begins as an immediate and unanalytic enjoyment ultimately cries out for an intellectual analysis of idea, form, and pattern; morality which originates as an automatic yielding to the dictates of conscience and training asks for principles of behavior and demands proof of the freedom of the will; religion which is born in a spontaneous outpouring of the soul finally seeks creeds and theologies. The demand for justification, therefore, is a demand for intellectualization. This seeking for reasons is, in the broad sense of the word, science itself. What this means is that the nonintellectual pursuits demand and receive justification in terms of the intellectual pursuits—morality in terms of ethics, art in terms of aesthetics, and religion in terms of the science or philosophy of religion. Thus science proves to be not itself a value pursuit but that unique feature of experience which is itself the justification of all value pursuits.

The truth which is involved in this claim unfortunately hides the error which is also contained in it. Science can, in a very significant sense, be said to be the justification of the nonscientific value pursuits. But this does not mean that science itself requires no justification. On the contrary, science demands justification on the same grounds and for the same reason that art, religion, and morality do. Is it not true that the scientist at an earlier or later point in the course of his work begins to be uneasy about the assumptions of his procedure—about the rationality, objectivity, and uniformity of nature, about the validity of the laws of logic, about the adequacy of communication? However unwelcome these guests may be in the house of science, they cannot be summarily dismissed. Whether he tags them "postulates" and allows them to remain,

whether he tolerates them on the pragmatic grounds that without them he would be unable to produce results, or whether he accepts their invitation to leave the scientific citadel and make an excursion into the realm of philosophy—in any case he recognizes that without an examination of these presuppositions science must remain unjustified. The analogy, therefore, between science and the other value pursuits seems remarkably close. So long as neither the individual or society has reached maturity an uncritical aesthetic experience, a cut-and-dried system of moral principles, a naive religion, and an unreflective science are entirely adequate. But when the individual reaches the age of discretion and when society attains a certain intellectual growth, dissatisfaction arises in all these activities. The experiences in their simple forms are no longer adequate to the increasingly complex situations to which the individual and society must make adjustments. Re-examination and criticism, rational justification, are called for, and the experiences undergo modification and extension. It is then that science begins to play its peculiar double role. The nonintellectual value pursuits require science for their justification; but science itself, being a value pursuit, requires for its justification that superscience which is commonly called philosophy. If we emphasize the one role of science—that in which it constitutes the justification of the other value pursuits—science seems fundamentally different from these other activities; but if we emphasize its other role—that of something which itself requires justification—we see its fundamental kinship to the nonintellectual experiences.

Enough has been said, perhaps, to indicate that science, interpreted as the pursuit of truth or knowledge, is in many significant ways strikingly like the other characteristic modes of value enjoyment. It remains to be shown how such a perspective on science enables us to see this discipline more clearly in the broader context of experience.

Similarity does not, of course, mean identity; whatever may be the results of our previous discussion, therefore, we should not think of science as without significant features of its own or as substitutable for the other value experiences. The unique character of any value activity lies in the value which is pursued. Since truth is not piety and goodness is not beauty, science cannot be religion nor morality be art. But this does not mean that the various modes of experience are unrelated. A man may be a better (or worse) scientist because of his piety, and he may be more (or less) pious because of his science; similarly, one's enjoyment of moral values may affect the pleasure which he derives from artistic values, and conversely. It must be remembered that man's experiences constitute an organic whole which should not itself be torn apart by the act of intellectual abstraction in terms of which we try to understand it. What is to be emphasized is that each of the value pursuits, uniquely characterized by the goal it seeks, nevertheless exhibits elaborate and complicated relationships to all the other values and corresponding experiences. Man achieves a satisfying life largely to the extent to which he is able to include the widest range of such experiences with the minimum of conflict between any two. Life is less adequate to the extent to which it is narrow, as in the case of the uneducated expert, the religious fanatic, or the aesthete who is idiosyncratic and socially maladjusted. Similarly, life is dissatisfying to the extent to which it is lacking in integration, however wide its sweep may be.

One of the most disturbing value conflicts, in the minds of many people, is

that which is commonly found between science and religion. The range and variety of solutions which have been offered to this important problem are a tribute to the intellectual genius of mankind. Most of these solutions, however, fall wide of the mark because they are based upon a fundamental misconception either of the nature of religion or of the nature of science. In view of the preceding discussion the points to be kept in mind seem comparatively simple. Science and religion are value pursuits of essentially the same kind. Their differences, so far as they exist, are to be found in the natures of the values which are pursued. The value experiences are satisfying to the degree to which the proper values are realized. But the values themselves, unfortunately, sometimes conflict. This hostility, or incompatibility, of values occurs over the total range of preferential judgments, from such simple situations as the impossibility of having our cake and eating it to the more sweeping and more profound conflicts of a Socrates who must decide between an honorable death and a dishonorable life. An individual is able to meet a situation of this kind adequately to the extent to which he has already built up for himself a satisfactory philosophy of life. Such a philosophy, based upon an inspection and analysis of the many possible values which life has to offer, expresses the individual's complete value perspective or value outlook. It usually takes the form of a value scale in which the many "bests" of life are so arranged as to indicate clearly which is *the* best and therefore never to be sacrificed for any of the others. The conflict between science and religion can be resolved in the only way in which such a situation can ever be adequately met, that is, with a minimum of sacrifice and accompanied by a recognition that the sacrifice is rationally grounded, if the individual is provided in advance with a value scale on which truth and piety have been properly located. If the religious value is deemed to be supreme in life and truth is given a secondary place, a conflict between truth and piety will require the individual, in all consistency, to sacrifice truth and believe on faith—accepting the small boy's definition of faith as "believing what you know ain't so." If the intellectual value is on top, the converse decision must be made, and the achievement of truth may, on occasions, involve acts of impiety. All this is, of course, an extreme oversimplification of the problem. It neglects entirely the fact that at times a higher value may be temporarily sacrificed to a lower one, that there may be a convergent value to which both truth and piety contribute, and that one's value perspective is itself a reflection of his experience, hence subject to change through intellectual growth and advancing years. But the principles for the resolution of the conflict seem clear. And they apply equally well in the case of an opposition between art and morality, art and science, religion and morality, or any other pair of value pursuits. What must be kept in mind is, first, that apart from a philosophy of life all the value pursuits, including science, are on the same level, and, second, that on the basis of such a philosophy alone can rational judgment be made.

Reference may be made, in conclusion, to the educational implications of this view of science. At one stroke the opposition between science and the humanities is eliminated, for science *becomes* one of the humanities. It is a significant enterprise of the human spirit with an exciting past and an enticing future, meaningless apart from human personalities, social groups, and cultural epochs. It therefore has its own history, psychology, sociology, economics, politics, geography, and philosophy. To argue that all these are not properly part of

science is to deny that they influence, and are in turn influenced by, science. In a broad sense where significant relations of interdependence exist, there the part-whole relation exists. To abstract science from this broader context is to reject factors that are essential to the proper understanding of the term.

May it not be presumed that the teaching of science, modified in the direction of less emphasis on specific factual material and more emphasis on methods, general principles, and cultural context, would be readily granted an important position in any college curriculum designed to produce a liberally educated man? No humanist, however antiscientific his prejudices might be, could possibly justify excluding it from such a program. Not only would science be required for a *general* education, it would be necessary even for a *humanistic* education; for the omission of science would be equivalent to the neglect of an important human undertaking. The student would not adequately know the humanities if he did not know science. That the traditional course in science would not meet this demand seems clear. Perhaps—though this might be argued—we need two courses in science, one for the future specialist, taught along customary lines, and the other for the student who is concerned with laying the broad foundations of a general education. All sorts of awkward problems involving matters of curriculum, administration, and even vested interests and human personalities would have to be met in the implementation of this broader view of science in the academic program. But it is helpful, I think, to have this alternative outlook before us—to see science, in other words, in that more inclusive social and cultural perspective in terms of which alone future problems—whether they be of atomic bombs, of the freedom of research, or of adequate living—can be solved.

NO SINGLE THING ABIDES*

No single thing abides; but all things flow.
Fragment to fragment clings—the things thus grow
Until we know and name them. By degrees
They melt, and are no more the things we know.

Globed from the atoms falling slow or swift
I see the suns, I see the systems lift
Their forms; and even the systems and the suns
Shall go back slowly to the eternal drift.

Oh Science, lift aloud thy voice that stills
The pulse of fear, and through the conscience thrills—
Thrills through the conscience the news of peace—
How beautiful thy feet are on the hills!

* This is a translation by W. H. Mallock of the first, second, and last (twenty-second) stanzas of the poem by the Roman poet Lucretius (Titus Lucretius Carus, 96–55 B.C.). It was provided by Karl P. Schmidt, Chicago Museum of Natural History, who regarded it as "singularly appropriate" for the SM.—Ed.

LIVING WATER*

By John G. Sinclair

Salty water flowing deep as life
From aged sea to ageless reborn cell,
The basic mead of man or protozoan gel,
Nor greatly altered in the potent strife
That molds all form unto adaptive ends
By which evolved it swims or runs or flies.
Most constant milieu which forever ties
Us to our past, where'er that past extends.

The sea, prophetic, brews a chemic charm
Of magic dielectric and ionic pawn,
Of balanced valence in a solvent strong,
And catalytic trace where more would harm.
Conservator of clime where syntheses survive:
Actinic polymers to hold the brief sunshine,
Ammonia with carbon chains combine.
Aminic pool in which the proteins thrive.

Strange oneness with the globe upon whose face
Life spreads a transient film, its narrow zone
Unique perhaps upon the earth alone.
In tenuous uncertainty it builds the race.
The balance on whose outcome life relies
Requires that each with constant skill enacts
The homeostatic juggler in unnumbered acts
And reproduce its likeness e'er it dies.

What maintains balance in this saline flood?
What trigger substitute for driving pain
Leads restless ones to salt and water gain
With stealth more certain than diviner's rod?
What ways devised to lose or reabsorb
Regardless how osmotic gradient lies?
"By vacuole and nephron," life replies,
"By rodded cell and capillary orb."

Salty water flowing the full span
From aged seas to cellular retorts,
Cyclotic streams to cytoplasmic ports
Or crimson bath to warm the heart of man.

* This poem was written in tribute to Dr. Robert R. Bensley and his family of helpers who have devoted many years to the study of the structure of living matter and the maintenance of its equilibria.

SCIENCE ON THE MARCH

WHOSE SKULL IS IT?

From time to time police authorities send me human bones that have been exhumed and turned over to them under various circumstances. It then becomes my job to tell them as much about the bones as I can, usually centering around three main themes: age at time of death, sex, and stock, or race. Incidental to these items I may offer some idea of stature and general body build. Obviously, much of this is predicated upon the receipt of a more or less complete skeleton.

Upon occasion I receive only a skull, with or without the lower jaw. It is frequently an Indian skull, unearthed in the preparation of a Victory Garden, or in digging a sewer main, or in excavating for a foundation. Once in a while an ancient, unmarked "old settlers' " cemetery is invaded by the march of civilization. More rarely, a skull is found which shows evidence of violent death—a bullet hole, or a depressed or radial fracture. In this instance the obvious occurrence of foul play raises the problem of the identity of the victim.

The restoration of the living head from the skull (so-called craniocephalic reconstruction) is not new. The technique has been employed in archeological investigations on many occasions. There are two main methods: a drawing is made of the skull, and cephalic details are superimposed—hair, eyes, nose, mouth, ears; or the skull itself is used as the basis for restorative sculptural modeling, that is, details of physiognomy are modeled over the skull, which serves as a core, or nucleus. The second technique is by far the more graphic, for it gives a three-dimensional restoration.

All restorations attempted up to now have been based on unknown skulls; it has been impossible to check the restoration against a known head. Thus, the head of Paleolithic or Neolithic Man has been restored from skulls found in caves. Obviously, it was impossible to do more than estimate how the owners of those skulls looked in life; hence it was impossible to check the accuracy and reliability of the restoration.

I decided to do something about this situation. Accordingly, I selected a male American Negro cadaver, aged forty-seven years, from the dissecting tables of the Department of Anatomy of The University of Chicago. In the entire experiment I went from head to skull to restoration and then back to the head as a check—a "triple play," as it were. As far as I know, this is the *first test restoration* that has been attempted and reported.

The problem was, of course, to provide a modeled head that would be a very reasonable facsimile of the individual during life. Obviously, a cadaver head has certain limitations as a real control. With death has come loss of tonicity, of the tissue resiliency that imparts life to physiognomic detail. Be that as it may, I measured the cadaver head and face in elaborate and precise anthropometric detail, paying especial attention to those mid-line features that impart racial individuality.

Dissection then proceeded on schedule. Finally, I macerated the head to obtain a cleaned skull, complete with lower jaw, and turned it over to my associate in the experiment, Miss Mary Jane McCue, a sculptress.

During the course of the dissection note was made of tissue thickness at various areas of the head and face. These data were retained by me for the final

checkup. I did turn over to Miss McCue the following information: (1) my analysis of the age, sex, and race of the skull, determined in the same manner as though the skull were that of an "unknown"; (2) a table of average tissue thickness on the heads of twenty male Melanesians (Oceanic Negroes), gathered from the literature; (3) a table of average cephalofacial sizes and proportions in American Negro males, reported by Todd and his associates. This type of information is useful as a general guide to the sculptress.

Up to this point I had three sets of measurements, none as yet made available for comparison with the restoration: (1) anthropometric measurement on the cadaver head; (2) tissue measurements on the cadaver head; and (3) anthropometric measurements on the skull.

The sculptress then went to work on her own, save for the data given her by me. My instructions were: "I want the restoration to have the resiliency of life and the individuality of a middle-aged male Negro physiognomy." In pursuance of this goal the sculptress, in the finishing phases of her restoration, persuaded a Negro janitor of comparable age to pose for details of ears and lips (structures not indicated by the subjacent craniofacial parts). The head was then made available to me for comparison. It was measured and photographed (front, left three-quarters, left lateral) and compared with similar measurements and photographs of the cadaver head

The measurements agreed astoundingly. With but one exception (bipalpebral breadth) all measurements, especially those of the important mid-line, agreed to within $\pm$ 1 mm. Most important of all, the restoration was recognizable as that of the subject chosen, allowing for the slack-jawedness of death and the firm-lipped reconstruction of living tonicity. We felt that the experiment—the *first rigidly controlled* craniocephalic restoration—was a success. The techniques employed may with confidence be added to the repertoire of medicolegal knowledge.[1]

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[1] For the details of this experiment see FBI *Law Enforcement Bulletin*, 15 (7), July 1946.

BOOK REVIEWS

THE VAGRANT MIND OF MAN

Adventures of the Mind. Arturo Castiglioni. Translated from the Italian by V. Gianturco. xviii + 428 pp. $4.50. Alfred A. Knopf, New York. 1946.

THE author of this interesting and scholarly book is a distinguished historian of medicine. Formerly a professor at the University of Padua, he was forced to leave his native land in 1938 when the Nuremburg racial laws were extended to include the Italian boot. Thus it was that Dr. Arturo Castiglioni came to America where he now teaches at the Yale School of Medicine.

Those readers who are already acquainted with the brilliant writing and erudition displayed by the author in his well-known *History of Medicine* may be assured that these qualities are not lacking in his latest book. Part of this volume was originally published some ten years ago in Milan. In its new and completed version, the translator, Mrs. Gianturco, has not merely translated the text, she has also preserved the lucid and scintillating style of the author.

Adventures of the Mind is essentially a study of the collective mind of man as it manifests itself throughout history. The thesis which the author attempts to expound is divided into three parts, each subdivided into nine chapters.

In part one, The Magic World, we find a fascinating discussion of magic among primitive men. This includes accounts of the functions of the magician, seer, and medicine man, of their personalities and powers, of their tools such as amulets, talismans, and fetishes, their practices, formulas, rites, and symbols, and even their secret societies. In part two we learn of Chinese magic of numbers and letters, the magic systems of the American Indians, the fantastic magic of the Hindus, the state magic of Egypt, Assyro-Babylonian speculative magic, Hebrew magic and the dawn of monotheism, magic and the mysteries of ancient Greece, and, finally, trends of official magic in ancient Italy.

Interesting as these earlier sections of the book are, the third part on the Decadence and Revival of Magic is, to this reviewer at least, the finest portion of the study. In masterly fashion Castiglioni gives us a compact outline of magic, witchcraft, and those strange manifestations of mass behavior which are called psychic epidemics and which seemed to be a peculiar characteristic of the Middle Ages. As examples of these psychic contagions which seemed to come as an aftermath of terrible disasters such as the Black Death may be mentioned the Flagellants, the so-called dance of St. Vitus, and the Children's Crusade of Schwäbisch Hill. By a strange coincidence, as this review is being written, there lies on my desk a copy of a daily newspaper dated July 6, 1946, with a story of mass suggestion and hysteria in which a nine-year-old boy in Poland repeated a medieval tale of witchcraft and ritual murder, thereby touching off a pogrom in which some forty people lost their lives. We see thus the ready parallels between the witch-hunts of the thirteenth to the sixteenth centuries and those of the twentieth. The hunting of witches, whether ecclesiastical or political, appears to be one of the chronic diseases of human society.

Finally, in attempting to find a solution to these collective diseases of the human mind the author examines such modern phenomena as the influence of Rasputin, Gandhi, Japanese secret societies, communism, nazism, and fascism. He attempts to characterize these mass

movements as examples of psychic contagion similar in their epidemiology to diseases of microbial origin. This is a most interesting analogy, but it does not seem to be a convincing simplification of a very complex phenomenon. Nevertheless, we must be grateful to the learned Dr. Castiglioni for a very instructive book.

MORRIS C. LEIKIND
LIBRARY OF CONGRESS
WASHINGTON, D. C.

THE WORLD OF SOUND

Die Welt des Schalles. Ferdinand Scheminsky. 2nd Ed. 820 pp. 189 illus. Verlag "Das Bergland-Buch," Salzburg. 1943.

A FASCINATING book! Its scope is vast, covering almost every phenomenon, every aspect, of sound. Sound production, perception, and related problems are presented in plain, modest, scientific language from which the traditional arrogance and painstaking "cloudiness" of German writers is wholly absent.

Ample credit is given to the work of American acousticians: for instance, Fletcher, in the field of overtones and sound perception; Sivian, Dunn, and White, on sound volume (dynamics); Edison and Berliner, for the discovery and development of the phonograph; Schmitt, Johnson, and Olson, on the chemical effects of sound.

While the book is semiscientific, it is very attractive, and even indispensable, to the musician since it gives the answers to many problems which puzzle the conscientious artist and shows him the way to their solution in practice. Of special interest in this respect are the chapters on tone volume, tone color, intensity and tonal qualities of the piano, the violin, and many other instruments.

Topics are grouped under five main headings with each part divided into several sections. The first part deals with sound and sound perception. It covers vibrations, their measurement, and the limits of perception by the human ear. An account is given of the effects of supersonic sound, for example on photographic emulsions, and of its lethal action on microscopic plant and animal cells—animals as large as fish have been killed by supersonic sound.

A discussion of how sound travels and its intensity and velocity under varying conditions is included, followed by a survey of observation, notation, recording, and various methods of artificial augmentation of sound waves. The relations between sound waves and their perception by the ear is analyzed, and this phenomenon is subdivided into tone color, pitch, and degree of intensity. Color is determined by partial or overtones which are present even in nonmusical noises. Pitch depends on the frequency of vibrations and on the amplitude of waves.

A more detailed picture of tone color follows, analyzing the influence of individual overtones upon the quality of the fundamental tone, making it mellow, soft, dark, bright, piercing, or thin.

Another section of great interest to the professional musician deals with pitch, color, and volume of sound as produced by standard musical instruments. It is demonstrated that the pitch of a tone is determined only by the first partial tone. The author points out the fact that the human ear reacts rather inconsistently to tones of equal volume but of different pitch, and its perception of pitch differences is limited. The development of scales among different civilized races is given, with interesting comments on the tempered scale, bitonality, polytonality, and atonality. The notation of musical tones is briefly sketched.

Physical loudness of tones is described as well as devices for amplification such as megaphones, funnels, and horns. Special mention is made of Beethoven's ear trumpets and the fantastic "Ear of Dionysius" in Sicily. The latter con-

sists of intricately shaped curvatures in the rock quarries of Latomia del Paradiso.

Various methods and apparatus for measuring sound volume are discussed, together with the reactions and limitations of the human ear in regard to volume. An amusing illustration is a passage from Schoenberg's *Gurrelieder* performed by 365 singers and players which, by actual scientific measurements, produced a fortissimo eighteen times louder than the roaring of a lion in the Berlin Zoo.

An analysis is made of sympathetic vibration and resonance and their demonstration through resonators. The resonance properties of the human body and those of monkeys and fish are examined. The necessity of resonance boxes is proved, particularly for stringed instruments, since strings are poor sound carriers. Chladni's tone patterns are mentioned.

A section is devoted to collision of sounds (combined tones). Here interference, cancellation of sounds, fluctuation (*vox caelestis* of the organ), artificial harmonic (Tartini), consonance, and dissonance are listed and demonstrated.

Sound in the open is compared with sound in enclosed spaces. This gives rise to a discussion of acoustics in halls and their often startling antics. As an example of measurement of distance and direction through sound waves, the author cites the fact that by projecting sound waves, ships at sea can ascertain the size of an iceberg at night and by calculating its volume avoid the obstacle.

The section concluding the first part of the book traces the development and usefulness of the phonograph for musical and medical purposes.

The second part of the book deals with sound production, beginning with a discussion of the patterns of sound waves of many types of sound-producing media, and continuing with the methods of tone production of many instruments, of speaking, singing, whistling, and of animal cries.

A third part deals with the functions of the organ of hearing in man and animals; another gives a picture of the role played by electricity in producing, conveying, and amplifying sound, with radio technique receiving due attention.

The last section is a collection of miscellaneous phenomena as a supplement, or appendix, containing descriptions of measurements of echoes useful for air pilots in determining altitude in foggy weather; flames as sound senders and receivers; supersonic ultrasound production by beetles; electrical instruments, such as an electrical violin capable of producing many times the volume of an ordinary violin; a survey of prehistorical instruments; and other topics. Interesting discussions on the sense of hearing drawn from a wide variety of works are given for mammals, birds, reptiles, amphibians, fish, and several invertebrate animals.

The book is amply illustrated by diagrams, reproductions of drawings, and photographs. An English translation would be highly desirable in view of its comprehensive and generally popular presentation of the material.

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ASTRONOMY FOR TEEN AGERS

Sun, Moon, and Stars. W. T. Skilling and R. S. Richardson. vii + 274 pp. Illus. $2.50. Whittlesey House. New York. 1946.

Sun, Moon, and Stars is a well-arranged presentation of the essential facts of astronomy written, as the authors indicate, for teen-age readers. The book introduces the reader first to the moon as the most conspicuous object in the heavens. The mature reader is somewhat startled to see relatively simple

words spelled out phonetically: Vesuvius (ve-sū'-vĭ-ŭs), occultation (ŏk-ŭl-tā'-shŭn), Colorado (kŏl'ō-rah'dō). One may perhaps wonder at the state of the intelligence of teen agers assumed by the authors. Certainly juvenile, grammar school, or even grade school pupils are well acquainted with the pronunciation of many words in geography. In writing simply it is always difficult not to write down. In general, however, the authors have been successful, and they fortunately avoided most of the subject material that could not be explained adequately to a child. The exposition of the somewhat difficult term "parallax," for example, is well achieved in explaining the method by which astronomers measure the distance to the moon and other inaccessible objects.

Part Two deals with the sun. Careful distinction is made between spectroscope and spectrograph, but juvenile readers may have some difficulty in evaluating the meanings of spectral lines and the account of the Zeeman effect in sunspots without a more complete background of the methods of spectrum analysis than the book contains. Sunspots are also described, and their effect on the earth is briefly mentioned. The authors miss an opportunity to tell radio-minded youths of the disturbances accompanying large sunspots, which may black out long-distance radio communication for hours or days at a time. An elementary introduction to atomic energy is presented in a comparison of the sun to an atomic bomb. Fortunately for the young reader, the authors refrain from any detailed description of the carbon cycle as a source of the sun's energy. With a suitable reference to Dr. Bethe and the statement that "four atoms of hydrogen are changed into one atom of helium and, in the process, 1/140 of the total energy of the hydrogen is set free," the subject is dismissed.

Part Three relates to the planets, their orbits, sizes, possible origin, and physical descriptions. The elementary knowledge of the cause of the seasons and the apparent annual motion of the sun and the motions of the earth are treated here. The discussion of other planets includes some of the best photographs obtainable. It is doubtful, however, that spectrograms will be generally intelligible to the class of readers for whom the book is written.

Part Four is devoted to the stars. This includes simple diagrammatic representation of the constellations, obviously drawn to stimulate familiarity with the heavens. There are simple directions for locating the constellations and there are descriptions of interesting objects such as nebulae, clusters, and dark clouds of the Milky Way.

The book closes with Part Five, which is devoted to astronomers, observatories, and their telescopes. Many of the photographs are excellent, but some definitely are of inferior quality. The book may be commended to juveniles, however, and, it is hoped, may stimulate young readers to take an interest in the fascinating science of astronomy.

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COMMENTS AND CRITICISMS

"Photomicrography"

A recent issue of a popular magazine published an article on "Microphotographs." I wrote to the editors to the effect that I understood that the proper term is "photomicrograph." My explanation was: A microphotograph is a very small photograph of any object. An example is the tiny rodlike lenses that were prevalent during the early gay nineties. By holding this lens very close to the eye, the picture could be discerned—usually an undraped figure. This gadget was frequently mounted transversely through the end of a fancy lead pencil. This, we maintained, was a "microphotograph." On the other hand, we believed that an illustration made of a microscopic object "blown up" to useful size was properly termed a "photomicrograph," i.e., a picture of a tiny thing as opposed to a tiny picture of an ordinary object.

The popular magazine courteously replied, thanking me for inviting their attention to the mistake and politely informing me that I had been equally at fault—that the proper designation could be either "*ma*crophotograph" or "photom*a*crograph."

In this dilemma I turned to Professor Irving Outcalt, the Dean of English and final tribunal of such questions. Professor Outcalt states: "'Photograph' is a recent word in our language, but it has been accepted as a word in good standing. Therefore it should be used as a word, intact. The practice of dividing it as in 'photo-macro-graph' is poor usage. The proper term to designate a photographic illustration of a tiny object is therefore 'Macrophotograph.'"

We therefore courteously suggest that J. V. Butterfield's excellent article in the July SM would more properly have been entitled "Color Macrophotography" and not "Color Photomicrography."—CHAPMAN GRANT.

Science and World Community

The article by Dr. Melvin Rader is for me the center of interest in the June issue of the SM. It echoes the nervousness of so many philosophers, scientists, and other learned men about the danger in which we all stand from the atomic bomb.

He commences by telling us that "all that we cherish may be destroyed because man's capacity to make scientific discoveries outstrips his capacity to control them." He goes on to tell us that "without a different sort of world view than has been prevalent we cannot make the arts of life prevail over the techniques of death." He draws attention to the generally recognized fact that "the old fixed concepts have broken down, and a new world view is emerging."

In the body of the article he points out that the transformations that create the atom out of the primary particles, the molecules out of the atoms, cells out of molecules, and living creatures out of cells stand for different levels of emergence. Also each level above the first represents an envelopment by the level derived from its predecessors. Thus the body envelops the cells, the cells the atoms, and the atoms the primary particles. He stresses the fact that science is finding more and more significance in wholes than in the parts of which they are constituted. They are more, generally far more, than the sum of the parts. To intrude an illustration that occurs to me, the atom is a balance made up of electrons, protons, and the rest of the primary particles. It has functions and potentialities that are quite different from those of the parts. This is sufficiently indicated when we note that its essential feature lies in the fact that it is a balance.

At this point Dr. Rader makes a statement that I will revert to later. It amounts to saying that since mentality has evidently developed long after the early levels of emergence, it is unlikely that all reality is mental. He also rejects the materialistic assumption that all reality is physical—that is to say, contained in sensory experience.

We are left without a clue to what he thinks reality is.

To revert to the article, our author points out that cooperation is quite as important an aspect of biological progress as survival of the fittest. The rule of tooth and claw is modified by many factors other than that of the struggle of the individual to exist. I regret that space forbids me to enlarge on a topic which is admirably dealt with.

So far the world presents the men who dwell in it with hopeful aspects. We may, *pace* the atomic bomb, look forward to a social development of a more benign type than has been known in the past.

Here, however, Dr. Rader introduces his doubts.

Knowledge has become so specialized and so unwieldly that it is hopeless to expect any one man to be able to view it as a whole. A great deal of research is wasted because the records

which deal with it are lost amidst hundreds of other records. The piling up of facts and their classifications defeats itself.

What the world wants is a great effort of synthesis as the result of an education to which no man may now attain. It follows that the intelligent guidance of the world, which can only arise from this supersynthesis, is actually becoming less and less possible with the increase of knowledge.

Dr. Rader gallantly concludes with a refusal to be downhearted. He holds that "it is unlikely that mankind could achieve the magnificent structure of science and yet could so wantonly misdirect it as to destroy the human race."

The article is typical of the current confusion of thought which has followed the crash of the old materialism. That has been sunk without leaving a trace. The universe presents to the modern scientist no vestige of mechanism. But the mechanistic type of thinking dies hard. Dr. Rader is speaking in terms of mechanism when he talks of stages of emergence and of the late "development" of mentality. The Freudian who regards man as a function of his sex furniture talks in terms of mechanism. The Darwinian biologists, who attribute biological progress to natural selection or some other specious concept, are talking in terms of mechanism. None of the people who cling to this kind of thinking appear to realize that they are flouting the well-established, if recent, finding of the physicists to the effect that the universe as known to them shows no trace of mechanism. This finding cannot be evaded by setting up mechanisms that are picked up out of the atmosphere created by the old materialism but have no other basis. What the creators of these quasi mechanisms are doing is to evade recognizing the only entirely objective reality, the only entirely objective fact, known to us. That fact is the certainty which each one of us has in the existence of his own personality. Every other fact, every other kind of experience, frames itself against this background. Further, since men live with and influence one another in ways that are not open to other beings and entities, man's confidence that his own personality is merely one among a great number of similar personalities is only less absolute than his confidence in his own existence. From this commerce of daily life has sprung the whole of knowledge, on its commensurable and incommensurable sides alike. Of course personality is simply a synonym for mentality. It is also a synonym for consciousness, purpose, perception, and indeed for every term that is an aspect of personality. Mentality can be given two meanings. In one it is a statement of the fact that man's every experience occurs within the framework of his personality and has no other claim to be called real. In the other meaning, it is extended to cover every entity in creation. Just as every man recognizes that other men exist with personalities akin to his own, so may he recognize that every entity that exists may in its real aspect be a personality. In this view, not only are the rest of the creatures that we regard as living, personalities, but the inorganic entities also are personalities, despite the fact that they are so far removed from us in form and function that this attribute is not ordinarily recognizable. In this view, the whole universe is a plenum of life, mentality, or personalities. In other words, it is a plenum of facts akin to the most objective fact known to man—the fact of his own existence.

I will not pursue this subject in detail here. I have written a book about it which can be consulted by those who are interested. I may, however, mention for the reassurance of proposed readers that it has been wholeheartedly approved by scientists of the standing of Jeans and Stromberg and that it has aroused the interest of Einstein. The modern scientist recognizes that physical reality is produced by superphysical agencies, which must be so designated because they can never be observed. The cosmos is a plenum of these agencies. When they operate to bombard our nerve terminals with photons of the frequencies that those terminals are constructed to accept, and when the bombardment takes place in mass sufficient to overpass the threshold of sensation, the process by some magic is translated into a sensation. But the frequencies that can be accepted are a minute fraction of the frequencies that exist; and this circumstance shows that human knowledge is confined to a tiny fringe of the total of cosmic reality. It is for this reason that the modern scientist no longer considers that he can explain anything. His function is confined to using the facts revealed by sensory experience and basing on them formulae of prediction. He recognizes that these formulae have no pretension to explain anything.

Thus modern science recognizes its own limitations. Beyond those limitations lies a vast plenum of activities which may be due to personalities, though modern scientists as a class avoid making this admission. It would be tantamount to an admission that the reality of the cosmos is spiritual, and, for people who have only very recently disengaged themselves from material prepossessions, this hesitation is understandable. I gather, however, that the scientific convenience of a vast unification, such

as that imposed by the acceptance of the vital interpretation, is gradually being recognized. There is absolutely no *scientific* objection to its acceptance. Every religion and every perception of the noumenal springs from an intuitive knowledge of the spiritual quality of the background of all existence. It is from these sources, and not from the commensurable type of experience, that the almost universal conviction of the value of human life and the importance of human conduct arises. This conviction is the only permanent defense against the atomic bomb and the rest of the terrifying discoveries of science.

I would conclude a letter which is far longer than I ever intended it to be by inviting Dr. Rader and the rest of our anxious intellectuals to study the philosophy of Leibnitz. He was a contemporary of Newton and shares with him the credit for inventing the differential calculus. Consequently he lived in an age in which matter dominated the speculations of science. In that day the atom was no more than an intellectual abstraction. Dalton, who made it the basis of a new chemistry, did not write till about a hundred years later.

And yet, in these surroundings, and with an extensive knowledge of physics of the Newtonian type, he gave to the world a philosophy identical with that which I have outlined in this letter. He called the personalities monads. He considered that every entity in the universe that is not a mere aggregate is a monad. For him the reality of every entity lies in this fact. His monads are simple, percipient, self-acting beings, the constituent elements of all entities. They are the very elements of nature. They do not have parts, shapes, nor extension. They are metaphysical points or, rather, spiritual beings, whose very nature is to act. Every monad mirrors the universe in its own way. Today we would say that it mirrors the universe in terms of its own sensory furniture. This circumstance leads to a fundamental harmony of perception based on diversity. This is the philosopher's celebrated "pre-established harmony" of the universe. Monads manifest themselves as aggregates or extended masses. There are no such things as absolute vacua, empty space, indivisible material atoms. The true nature of substance is energy. There are ruling monads—ruling because they seem to rule. Here Leibnitz gives the human body as an example in which the ruling monad, which is the soul, seems to coordinate the multitude of monads which constitute every particle of the body. He tells us that space and time are merely relative. We must here recognize that Leibnitz has foreseen the entire picture of the universe as it presents itself to the modern scientist under the aspects of relativity and quantic physics. That he was able to do so some two hundred years before these types of physics existed is simply miraculous. And yet it is all there. Explain it who can.

I know of no work on Leibnitz that presents it in terms which bring out his exceedingly modern significance. The latest that I know was written by Bertrand Russell in 1900. It is a most learned and able work but misses a significance that was not discernible at that date. The recent edition of the *Encyclopaedia Brittannica* has, however, a very fine article on Leibnitz, which is the source from which I have taken my brief notes on his philosophy.—SIR RICHARD TUTE.

The Biological Basis of Imagination

Congratulations and commendations on "The Biological Basis of Imagination" article in the June SCIENTIFIC MONTHLY. Dr. Gerard has performed a notable public service in assembling the facts which are presented in this article. Every student and thinker could well profit by reading it.

My co-worker, Professor Harry La Verne Twining, was particularly enthusiastic over the presentation and declared that it bears out his own experience in solving problems relating to space and atomic energy.—FRANKLIN LLEWIS.

Lady of the Lagoon

Up from the sea that covered her,
Blown full-fledged with the waning moon;
Rainbowed, the head and neck of her;
Bombed, our Lady of the Lagoon.

No atoll ever was so struck;
Nor sea ever surged by typhoon;
No hair ever singed by such ruck:
Gone—the Lady of the Lagoon!

HOWARD S. ANDERS, M.D.

The foregoing lines were written by Dr. Anders after he saw the now well-known news-photograph of the second Bikini test. Here, thought Dr. Anders, was not the "Lady of the Lake" but the Lady of the Lagoon. In an attached note he added: "Can you imagine an M.D. of 56 years of practice, and pioneering and fighting in the fields of preventive medicine, public health, and municipal sanitation falling for the eight lines that this note introduces?"—Ed.

THE BROWNSTONE TOWER

This may be the last editorial I shall write in the Tower of the Smithsonian, for the A.A.A.S. building on Scott Circle is nearly ready for occupancy. Although I did my best in the SM to stimulate contributions to the Building Fund and will continue to do so for the sake of the A.A.A.S., I regret my impending departure from the Brownstone Tower. One could not have a more inspiring office than mine for editorial work. Situated in the flag tower of a building so famous that it is now the subject of a commemorative postage stamp, my office is comfortable and secluded, yet looks out upon some of the shrines of our country. But my attachment to my office does not rest entirely on its situation. It is full of happy associations: of three years of labor with loyal assistants, of pleasant acquaintanceship with members of the Smithsonian staff, and of successful struggle to overcome the effects of illness and death.

My new office at 1515 Massachusetts Ave., if lacking in glamor, has its compensations. It is situated on the second floor of the house shown on page 556 of the June SM. Having an ivy-covered bay window facing Massachusetts Ave., it might pass as a tower room if the rest of the house is disregarded. This room is about twice the size of my present office. It has a fireplace, which, whether functional or not, will add to the possibilities of furnishing the room attractively. I shall occupy this room alone, for my assistant will have a smaller adjacent room over the front entrance. Thus we should be able to work more efficiently than we can now. Our move to the new building will be marked by the elimination of the cut of the Brownstone Tower from this page. But the title of this column will be retained in memory of the owls.

Everyone must know that August 10, 1946, was the centennial of the founding of the Smithsonian Institution. The A.A.A.S. observed the occasion by devoting the August 9 issue of *Science* to a review of the history and accomplishments of the Smithsonian. To maintain interest in the centennial we decided to defer the SM's tribute until the November issue. That issue, we hope, will be devoted largely or entirely to contributions from members of the Smithsonian staff.

In the present issue we offer an unusual story on which some editorial comment may be desirable. I refer to Dr. Shimkin's experiences in bringing first aid to the newly liberated victims of a German concentration camp. It is not science. It is not even about science. It is a grim story of horror and anger and compassion told by a scientist who is also a human being. We accepted it to remind our readers that science is merely a refinement of civilization. Without a core of basic virtues centered in love, civilization is a hollow shell that scientific knowledge cannot save. There *is* truth that does not have to be confirmed by repeated measurements. "Charity never faileth: . . . ; whether there be knowledge, it shall vanish away." One need not take refuge in the supernatural to know the reality and importance of Christian virtues. To add scientific knowledge to the practice of these virtues is to live happily and usefully. To get knowledge without humanity is insane.

Consider, by contrast, the international good will inherent in the present article by R. L. Steyaert on the Belgian Congo. Dr. Steyaert, probably the only member of the A.A.A.S. in central Africa, sent us his manuscript as an expression of appreciation for the pleasure he has derived from the SM. Let us hope that scientists throughout the world will follow Dr. Steyaert's example.

F. L. CAMPBELL

THE SCIENTIFIC MONTHLY

NOVEMBER 1946

THE SMITHSONIAN IN A WORLD AT WAR

By C. G. ABBOT

RESEARCH ASSOCIATE, SMITHSONIAN INSTITUTION

IN Oliver Wendell Holmes's famous poem "The Deacon's Masterpiece: or the Wonderful 'One-Hoss Shay'" we read:

> Little of all we value here
> Wakes on the morn of its hundredth year
> Without both looking and feeling queer.

The Smithsonian Institution at its century mark finds itself in a world filled with strife. Groups, parties, governments, and individuals seem to have gone over to the view that only by selfishly fighting can they hold their places in the sun or better themselves. If they better themselves, it must be by others' loss.

This is so contrary to the faith and policy of the Smithsonian Institution, both at its foundation and throughout its century of being, that the Institution, as Dr. Holmes says, is in the way of "looking and feeling queer," almost out of place and incongruous, indeed, in such a world as now surrounds it.

Its founder, James Smithson, gave only the simplest of conditions with his gift. It was "to found at Washington an establishment for the increase and diffusion of knowledge among men." He believed that increase and diffusion of knowledge is a boon and he desired it for all men. There are those in our time who suggest that increase and diffusion of knowledge is an evil, because it gives evil men greater capacity to do harm. But we have only to take the long view, looking back to the Stone Ages, to see plainly the contrary. Knowledge extends and saves life, fills it with comforts, and removes fears of old bogeys.

What a statesman James Smithson was! He gave his fortune to a young and vigorous nation, untrammeled by the conventions of long-established institutions. He attached no hampering conditions, trusting in the wisdom and good will of those who would administer the gift in all future time. One needs only to compare this policy with what happened to the bequests of Benjamin Franklin to see the wisdom of Smithson.

Benjamin Franklin, dying in 1790, bequeathed £1,000 each to the cities of Philadelphia and Boston; his bequest was hedged about laboriously with conditions. The gifts were to be administered by trustees of special types—particularly described by Franklin—for the purpose of making loans to "young married artificers." Applicants must have served apprenticeship in either Philadelphia or Boston and be certified as of "good moral character" by at least two responsible citizens, willing to be sureties for the repayment of the loan at 5 percent or more. Not more than £60 or less than £30 was to be loaned at a time and one-tenth was to be repaid with interest each year. Franklin went on to compute the values of the trusts at the ends of one and of two centuries and specified that after one century £100,000 of each

fund should be devoted to public improvements, "as fortifications," and the balance to be employed as before during the second century.

The upshot was that the terms of the bequests could not long be carried out, and both were adjudicated by the courts. Neither bequest received anything like the accretions Franklin computed, and both were assigned by the courts to other objects than those he proposed.

Not only did James Smithson give a statesmanlike and altruistic example, but the policy laid down by Joseph Henry, the great first Secretary, carried the Institution forward in the same unselfish line. He held that the wording "increase and diffusion of knowledge among men" was deliberately and intelligently employed. No local or even national interests limited the scope. Knowledge was to be promoted by original research, and it was to be diffused as widely as possible to all mankind. If projects undertaken by the Institution were adopted and adequately continued by others, the Institution should withdraw and devote its means to other, more needy, projects.

Such were Secretary Henry's wise and altruistic policies. They have continued to be the Institution's policies for a hundred years. But now we see more and more governments, unions, and groups concentrated under the control of supermen. The rank and file receive their orders from central authorities and for the most part follow blindly. In short, the social methods of the ants and bees seem to be more and more recommended and followed throughout mankind.

This practice is the antithesis of the views of the Founding Fathers and of Smithson. They wished to promote knowledge and wisdom among all the people, so that all should take helpful and intelligent parts in public affairs. Ants and bees, indeed, provide for food and shelter and defend their domain from assault. This they have done for thousands of years, neither better nor worse now than formerly. But man, by the increase and diffusion of knowledge, has advanced at the same time from beastly barbarism to civilized culture.

The ideal we follow, of self-government by enlightened people of good will and steadily growing knowledge and wisdom, is perfectly attuned to the principles and practice of the Smithsonian Institution. The adoption of forms of government incompatible with good will and subversive of the universal diffusion of knowledge leads backward toward the Dark Ages and beyond.

There are two methods of protecting the individual. Among beasts and vegetation, and largely among men, the individual fights for his own advantage. This is the primitive method. The other must await the growth of the mind and of altruism. Confucius, some 2,500 years ago, said negatively in these express words: "What you do not like when done to yourself, do not do to others." Jesus Christ, about 500 years later, stated it in the positive sense: "As you would that men should do to you, do ye also to them likewise." If these precepts were universally followed, and wisdom as well as altruism were diligently sought, all individuals would be cared for, since everyone would intelligently seek the interest of every other. And this would be a world of love and not of hate.

It has been a long time since these precepts were promulgated. They are too little heeded. But in an atomic age, if the world continues to practice the primitive method of the survival only of the strongest and the overawing of the weak, will not civilization fade away?

SCIENCE IN UNESCO

By BART J. BOK
HARVARD COLLEGE OBSERVATORY

Since wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed.

AT THE height of the war, about two and a half years before the United Nations Organization was created at San Francisco, a group of allied ministers of education held a series of conferences on postwar problems of international cultural collaboration. These conferences, held in London in the fall of 1942, mark the beginning of the United Nations Educational, Scientific and Cultural Organization (UNESCO). At first the participants to the conferences were only representatives of Great Britain and a group of ministers of education of governments-in-exile, but early in 1943 this group was enlarged to include delegates or observers from the United States, the Soviet Union, China, the British Dominions, and India.

By April 1945, at the time of the San Francisco Conference, the need for an educational, scientific, and cultural organization directly under the United Nations was realized by many groups, governmental as well as others. In the United States our State Department was taking an active interest in the proposals and, following the San Francisco Conference, Under-Secretary of State Archibald MacLeish was one of the most active participants in the planning for an effective organization under the United Nations. Private individuals and organizations gave their support to the plans. The American Association for an International Office of Education, with James Marshall and Harlow Shapley as the principal spark plugs, worked consistently for a strong organization and for effective participation by the United States. The American Association of Scientific Workers submitted a number of proposals for the activities of the scientific division of the international organization.

Congress showed an early awareness of the need for an international organization of a cultural nature. On May 22, 1945, the House of Representatives adopted the Mundt Resolution calling for an international organization, and two days later the Senate passed the comparable Taft-Fulbright Resolution. Both resolutions were carred unanimously.

THE Charter Conference of the United Nations Educational, Scientific and Cultural Organization was held in London in November 1945. The London meeting, at which forty-three nations were represented, drafted a constitution for the newborn organization; the quotation at the head of the article is from the preamble to this constitution. The delegates of the various nations affixed their signatures to the UNESCO constitution and then returned home to request formal ratification by their governments. According to the constitution, UNESCO really came into existence following ratification by twenty of the nations represented at the Charter Conference. To carry on the organizational work and planning for UNESCO, there was established in London a UNESCO Preparatory Commission, of which Dr. Julian Huxley, the well-known British zoologist, is the Executive Secretary.

Since UNESCO will deal with the whole field of international relations in

education, science, and culture, several divisions were created under the Preparatory Commission, one of them a Natural Sciences Division. It was indeed appropriate to have Dr. Joseph Needham head of this division, for Needham is the man who did as much as anyone to put the *S* into UNESCO. When in 1944–1945 the first plans were under discussion, there were several powerful groups in our own country and abroad that attempted to limit the activities wholly to the educational and cultural aspects of international relations. Scientists in the United States, France, China, and Britain rose in protest against a lopsided UNECO (without an *S*); it was Needham, as a spokesman for the British scientists, who first urged the change of name from UNECO to UNESCO.

In November of this year UNESCO will hold its first full-fledged conference at Paris. The Preparatory Commission will then present, for consideration the initial program for UNESCO and at the conclusion of the Paris Conference the new organization will begin actual operations, with its headquarters in Paris.

Our State Department, assisted by the various groups interested in UNESCO, has taken an active part in the work of the Preparatory Commission. Mr. Charles A. Thomson, of the State Department, has been the coordinator of most of these activities. To aid in the planning for the Natural Sciences Division, the Secretary of State appointed a Scientific Advisory Group, with Dr. Detlev Bronk, representing the National Academy of Sciences and the National Research Council, as chairman. The members were Charles E. Kellogg, Howard A. Meyerhoff, W. Albert Noyes, Jr., Stewart E. Reimal, Harlow Shapley, Merle Tuve, and Raymond L. Zwemer; Rollin Atwood was the Executive Secretary of the Group. The Scientific Advisory Group acted as a clearing house for suggestions and collaborated closely with the Preparatory Commission in London.

A bill for the ratification of UNESCO was passed without difficulties or delays by both Houses, and the United States formally joined UNESCO on July 30, 1946, when President Truman signed the bill. The bill calls for the creation of a National Commission on Educational, Scientific and Cultural Cooperation with a total membership not to exceed one hundred. A maximum of sixty representatives may be appointed by the principal national organizations interested in matters related to UNESCO. The Secretary of State is authorized to select the remaining forty members.

On September 18, 1946, Assistant Secretary of State William Benton announced the composition of the first U. S. National Commission for UNESCO. It is disappointing to find that six of the seven scientists of the Scientific Advisory Group were not invited to join the National Commission. The five natural scientists among the ninety members of the National Commission are Arthur H. Compton (member-at-large), Detlev Bronk (for the National Research Council), James B. Conant (for the A.A.A.S.), Reuben Gustavson (representing State and Local Government) and Ross G. Harrison (for the National Academy). Although it has been generally accepted that the natural sciences should be responsible for at least one-sixth of the activities of UNESCO, they are given about one-twentieth of the job by the State Department.

Neither our State Department nor the UNESCO Preparatory Commission has issued public reports about the program of activities for UNESCO to be submitted to the Paris Conference in November. Out of the welter of sug-

gestions made so far, the general program for at least the Science Division begins, however, to emerge. It is a preliminary and highly flexible outline of a program, and anyone who attempts to assign tentative priorities does so in the realization that the order and emphasis are bound to be changed when the democratic process starts operating in full at the forthcoming Paris Conference. It is, however, high time for American scientists to give more than casual thought to the program for UNESCO. At the November Conference in Paris definite plans will be made; the time to make one's voice heard is now.

It would lead too far afield to examine the outline for the full program of UNESCO, and we shall therefore limit ourselves here to an examination of some suggestions for activities of the Science Division.

When planning for UNESCO, a scientist must keep in mind that the "construction of the defenses of peace" is the primary aim of the new organization. Science comes to UNESCO to make a contribution to world peace and international understanding and *not* to feed surreptitiously from an international trough. If, by accident, UNESCO should be able to serve the advance of science, so much the better, but we should not outline its program with that as our primary aim.

The UNESCO planners are facing the difficult task of building a program which blends effectively long-range schemes of obvious importance for international relations and short-range projects that can serve to dramatize promptly the potentialities of international collaboration. Under the present precarious conditions for world peace, a limited project that begins to pay dividends right away may be more valuable than an extensive one of which the full benefits will not be realized until five or ten years hence.

Most proposals for UNESCO activities that I have seen agree that exchanges of scientists, young and old, should rate top priority. Unless scientists are given the opportunity to travel, science will become institutionalized and provincial in outlook. Young research scientists and students need to travel to get a broader outlook on their prospective fields of investigation. Older men and women want the stimulation that comes from contacts with friends and colleagues from other countries. Scientists from backward nations, young and old alike, will need periods of study at the great research centers of the world. In turn, the backward nations will require for their development visits of varying duration from scientists of countries where favorable conditions for research exist.

UNESCO is in a position to promote exchanges in a variety of ways. The establishment of a number of UNESCO fellowships appears almost certain. What could be better propaganda for internationalism than two or three hundred UNESCO Traveling Fellows? The American Chemical Society has already offered ten graduate fellowships of this nature. Fellowships are relatively easy to administer, and not much time is required for the selection of capable and internationally-minded scientists. In the discussions of the past few months it has been stressed that exchanges should be arranged at all levels. Students, technicians, teachers, research men, from the little fellow to the Academician, all have their special contribution to make to world peace and international good will. Shapley has made the suggestion that UNESCO could well sponsor "Traveling Panels," composed of experts (no two of them of the same nationality) traveling as a group from one local cultural center to another, staying at each center for not more than one or two weeks. The members of the UNESCO Panels

would be available not only for technical conferences and seminars, but also for illustrated lectures to the general public.

Frequently UNESCO will act only as a coordinating agency and may request a government or a research foundation to award certain fellowships. In some cases UNESCO may do no more than provide suitable letters of introduction, and there has been some talk of "UNESCO passports" for bona fide traveling scientists.

UNESCO should include engineers in its system of exchanges. A suggestion which has appealed to me is that of truly international technical commissions with the UNESCO label. If the government of China, for example, wishes the aid of a technical commission to advise on a flood-control project, there is much to be said for a UNESCO commission with representatives from several nations, as opposed to the customary type of advisory commission set up by a single government.

ONE of the principal points of argument at the London Conference of November 1945 was about the role which UNESCO should play in connection with the rehabilitation of scientific institutions in devastated countries. After long debate it was decided that UNESCO should survey the existing needs and make recommendations for reconstruction measures, but that the actual execution of the rehabilitation program should be in the hands of other UN organizations or of national governments. The Preparatory Commission and our National Commission are both aware of the urgency of scientific rehabilitation. With UNRRA gradually winding up its affairs, the responsibility for presenting a comprehensive program becomes that of UNESCO. The Preparatory Commission has argued that the task of scientific rehabilitation should be largely entrusted to the Natural Sciences Division. Our National Commission is pointing out that special appropriations will be needed if UNESCO is to undertake the work.

In the field of abstracting, UNESCO will probably be the organization to make comprehensive surveys of the needs. It will be in keeping with its status as a coordinating agency not to interfere with existing abstracting organs but to encourage their work. Wherever a serious gap is found to exist, UNESCO should take whatever steps appear to be necessary, but only in case no other solution is in sight should UNESCO itself become involved in the setting up of an abstracting service.

In the end UNESCO will probably work for some sort of unification in scientific abstracting. It is clearly within the mandate of UNESCO to facilitate in every way possible the prompt interchange of information. Within a few weeks after publication, reports of research published in any one country should be available everywhere in the world, at least in English and French and preferably also in Russian.

An important phase of UNESCO's work will be in the field of science education of the masses. Movies, radio, and microfilm will all play their part in this work. Some sort of international science news service will have to be established under UNESCO. It is clearly the function of UNESCO to inform the public everywhere on the bearing of scientific discoveries on international relations.

THE Preparatory Commission for UNESCO is laying the foundation for effective collaboration with other international agencies, the UN Atomic Energy Commission, for example. Preliminary discussions with representatives of the UN Food and Agriculture Organization, of the International Health

Organization, and of UNRRA indicate that the Natural Sciences Division of UNESCO will probably become the central scientific coordinating agency in the United Nations Organization.

One of the expressed aims of UNESCO is to do everything possible to support the work of the International Council of Scientific Unions. UNESCO's support has been promised to those international unions that are entitled to it. Here again the function of UNESCO will not be to supplant existing organizations, but rather to facilitate and assist those which show the greatest promise of being of service to the cause of good international relations. In the prewar years the young Committee on Science and its Social Relations was one of the most hopeful developments under the International Council of Scientific Unions. With the joint support of the International Council of Scientific Unions and of UNESCO, this Committee may become an integral part of the Economic and Social Council.

THE planners for UNESCO's scientific activities are all active scientists and not bureaucrats. They do not wish UNESCO to become a top-heavy bureaucratic organization. There will be a central office in Paris, but this should in no way dominate the activities of the world-wide organization. Following an original suggestion by Needham, there are plans afoot to set up a series of regional science cooperation offices. Where the Unions represent the various sciences on a worldwide basis, the regional UNESCO offices will cover all sciences, but they will serve primarily the regions where they are located. The Unions are now strongest in the centers of intensive, advanced scientific activity, but some regional offices can also be established in scientifically backward areas. In recommending the setting up of these offices, the Preparatory Commission recognizes that one of UNESCO's principal functions is to spread the benefits of scientific advances wider than has hitherto been the case.

Exchanges, abstracting, collaboration, coordination are useful, but a program built on them alone will lack the drama needed to make UNESCO an effective agency for world peace. Various governments have suggested that UNESCO should foster some International Institutes carrying its name. There is, for example, much support for an International Center of Applied Mathematics, to be located somewhere in Asia, probably in India. There may be one or more International Nutritional Laboratories, an International Resources Office, an Equatorial Tropical Survey Institute, and others like them. The International Astronomical Union has requested that one or two "UNESCO Observatories" be established (preferably one in the Northern Hemisphere, the Mediterranean region; the other in the Southern Hemisphere, South America) with the most effective modern telescopes and accessories that can now be built. Such observatories would give the astronomers of, for example, Poland, Belgium, China, and Uruguay opportunities for observational research equal to those of their colleagues in the United States. In turn the credit for the discoveries made at the UNESCO Observatory would go not only to the nation to which the individual discoverer happens to belong, but also to UNESCO and the cause of international collaboration. The UNESCO Observatory on its mountain-top may well become the symbol for internationalism.

IT HAS been unfortunate that up to this point the Soviet Union has not participated in the preliminary work of UNESCO. The reason given for the Soviet refusal has been that the Soviet Union cannot collaborate until UNESCO

has become formally a member organization of the United Nations. Informal assurances have, however, been received that the Soviet Union will join UNESCO soon after the new organization becomes a permanent UN agency. The supporters of UNESCO are without exception eager to see the Soviet Union in the new organization. Without USSR participation UNESCO will be unable to fulfill its truly international functions. UNESCO can do no greater service to world peace than through the development of certain scientific exchanges between the Western nations and the Soviet Union.

WHAT can we scientists as individuals do to promote UNESCO? First, we must all acquire the habit of thinking hard about UNESCO and its function in the international order. Second, when we arrive at conclusions or have suggestions about the program for UNESCO, we should make these known to the National Commission, either individually or through our organizations. Third, since November 1946 is to be the "UNESCO month" and since the third week of November of this year will be "UNESCO week," we should in our communities arrange at that time for lectures, exhibits, and conferences on UNESCO and its role in world affairs. Fourth, when early in 1947 UNESCO's program gets really under way, American scientists should do all they can to make it a success.

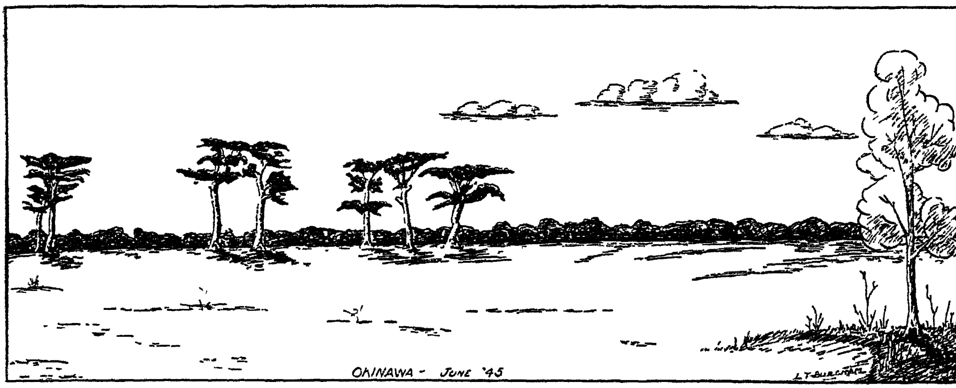
UNESCO can and will succeed if it has the united support of all men and women of good will. Fortunately they are still in the majority in the world of today.

BART J. BOK AND UNESCO

Explaining his interest in UNESCO, Professor Bok writes: "My interest in UNESCO is one phase of a lifelong interest in international relations in science. I met many of my friends of today (including my wife, Priscilla Fairfield Bok, who is the co-author of our book on *The Milky Way*) for the first time at a meeting of the International Astronomical Union at Leiden in 1928, when I was an astronomical student in Holland. I received most of my training in Holland at the Kapteyn Laboratory, the headquarters for the Plan of Selected Areas, an international enterprise for the study of the structure of the Milky Way System.

In recent years I have been the chairman of the American Astronomical Society's wartime Committee on the Distribution of Astronomical Literature and I have been to Mexico three times, as the guest of the Mexican government, to help in planning for the Observatorio Astrofisico Nacional de Tonanzintla.

For some time I have been chairman of the International Relations Committee of the American Association of Scientific Workers. For the past year and a half this committee has worked on the program for UNESCO and as chairman of the Committee it has been my privilege to speak out privately and publicly on the subject."



BIOLOGICAL COLLECTING DURING WORLD WAR II*

By EGBERT H. WALKER
ASSOCIATE CURATOR, U. S. NATIONAL HERBARIUM

IT HAS been said that life in the Army and Navy, even in wartime, consists largely of long, boring waits interspersed with occasional violent activity. In order to offset the morale-killing effects of those long inactive hours, many scientists back home urged and assisted hundreds of servicemen during the war to take advantage of their idle hours and their interest in their new surroundings. They were asked to collect and send home specimens of the plants and animals they found about them. These would be added to the permanent research and study collections in museums and schools, thus enabling the servicemen pleasantly to turn waste time into solid accomplishment.

That this was no idle vision on the part of the scientists, many servicemen's letters bear witness. For example, Lieutenant D. C. Olsen, of the U. S. Army, a forester in civilian life, wrote: "I regret that I wasn't aware of your desire for specimens during the year and a half of cruiser duty I have recently completed. I had many opportunities to collect specimens in New Caledonia, New Hebrides, the Solomons, and the Admiralties." One man, a former botany student, suddenly discovered, when he was asked to collect plants, that even Army life could be interesting and soon wrote that he and his wife were determined to return to New Guinea after the war to resume collecting where he left off when transferred to the Philippines. He has now returned to his graduate botanical studies with a new purpose and enthusiasm. Many men were intensely interested in the natural life around them. Lieutenant W. H. Wagner, in the Naval Air Transport service, wrote:

On any clear day a number of servicemen could be seen on the reefs bordering Kwajalein Island turning over rocks and watching small tidal pools to catch sight of the tropical marine fauna, including such diverse animals as sea-

* A scene on Okinawa, drawn by Captain L. T. Burcham, is shown above the title. The trees are probably the riu kiu pine (*Pinus luchensis* Mayr). The only specimens of this plant in the U. S. National Herbarium were presented by servicemen.

cucumbers, moray eels, slate-pencil urchins, hermit crabs, and brilliantly marked reef fish.

The number of people and institutions encouraging and assisting these men is unknown, but it is considerable. It includes parents, wives, friends, former professional associates and teachers from high school up, natural-science professors, museum workers, professional associations, especially the Society of American Foresters, and fellow-servicemen and officers. Professor H. H. Bartlett, head of the Department of Botany of the University of Michigan, developed an informal interinstitutional cooperative program aimed to coordinate the scattered interest and to provide more facilities for identifying the material collected, thus encouraging the collectors. This group worked in part through the United States National Herbarium under the Smithsonian Institution, largely because of its advantages as a governmental organization and its potentialities as a clearinghouse for collections received, and because of its need, as one of the nation's public herbaria, of increased collections from all parts of the world. Helpful literature was provided[1] and hundreds of letters were written to servicemen, whose interests and potentialities were determined through numerous and varied channels.

The underlying motive of the promoters of this servicemen's collecting program was partly to enlarge existing scientific reference collections, taking advantage of the unprecedented dispersal of biologists throughout the world. Another motive was to assist the young scientists and potential scientists, diverted from their normal careers by necessary military service, to retain their interest in natural science. Thus the failure to provide for the future increased need for scientific personnel through draft deferment would be at least in part offset. Also, scientists at home were being deluged with requests from servicemen for help in identifying the plants and animals around them and for books on the trees, orchids, fishes, birds, and other organisms. Ensigns Leupold and Ruth, graduate foresters, wrote from the Pacific, "The vegetation on this island is varied and very interesting, but we lack means of identifying any of the trees and shrubs or annuals. We are making a collection of all the species of vegetation and preserving them by drying." What they and many others wanted was a "Gray's *Manual*" for the Southwest Pacific. As there were no such works in existence for the Pacific, the Aleutians, or the Far Eastern theatres, the men were urged to gather the materials from which the manuals of the future could be prepared.

How successful the serviceman's collecting program was in attaining its objective of increasing scientific collections and providing future biologists cannot be entirely determined. The 6,000 plant specimens received by the U. S. National Herbarium in 1945 are probably only a small part of the whole. How many men have been saved from lives of boredom and will become scientists, only time will tell, but there are enough budding and enthusiastic botanists and zoologists from this source now working for advanced degrees to give us much satisfaction. Their perspectives are wide, for they have been places and seen things that few American botanists have seen. We can only hope their teachers and advising professors can and are willing to maintain their broad interests so that they will extend the outlook of American botany and help this country to assume the leadership in world botany which now lies open to her. Professor Bartlett wrote one of them, "It is little short of scandalous that American scientists have done so little over so much of the world."

[1] E. H. Walker. "Natural History in the Armed Forces." THE SCIENTIFIC MONTHLY. 61, 307–312, 1945.

Germany has been the acknowledged leader in the world-wide aspects of natural science, botany especially. Will she remain so after World War II as after World War I? It seems unlikely, at least if this country has sufficient broad-visioned teachers and students.

The servicemen and women who participated in this collecting occupation were a varied lot, ranging from commanders to privates in all branches of the service. The majority seem to have been lieutenants, judging from my list of 38 collectors and over 166 correspondents. One excellent collection was turned in by a woman Red Cross welfare worker on Attu Island. Besides other collectors in the Aleutians and Alaska, there were avid workers in all parts of the Pacific theatre, including Australia, Burma, Assam, and India in the Far East, and a few localities in Europe. Some institutions have received specimens from Africa, South America, Greenland, and Iceland which were collected by members of the armed forces.

THE purposes of the men in taking up scientific collecting were many and sometimes novel. Most men were, like the ensigns just quoted, overwhelmed by the desire to learn about their surroundings through collecting. Some dyed-in-the-wool collectors, denied access to postage stamps, just could not help collecting. A misplaced gynecologist major in the medical service in the Aleutians, having little else to do in that womanless land, made a beautiful collection of plant specimens for the Chicago Natural History Museum that was worthy of public display. A zoologist wrote from Guam that boredom forced him to collect plants after exhausting his specialty, the snakes and other reptiles. A captain in Africa wrote for directions on how to collect insects, saying, "Unfortunately for our comfort we have what seems to be an unbounded supply of material, and I would like to make some use of them." Some had genuine urges to contribute to scientific progress, while others, though willing to help the cause, wanted first to assemble material for their future study for advanced degrees. A high staff officer, an ardent rock gardener, sought material in the Aleutians for his future peacetime back-yard avocation and gathered duplicate material for identification. Some collections were made in the line of duty by medical research men and those engaged in sanitary surveys.

Probably many specimens of potential scientific value were gathered with no such motives in view but rather just to startle and amuse the folks back home. Many will eventually drift into scientific collections. A navy lieutenant, fascinated by the gorgeous display of flowers in the Grampian Mountains in Australia, took kodachrome pictures and then wisely made pressed specimens for use in obtaining identifications. We heard of a colonel who relaxed by painting the orchids about his Burma headquarters, but we were unable to persuade him to press the specimens so they could enter the orchidologist's files while his paintings adorned the art galleries. A high naval officer in the Admiralties collected specimens to be identified for use in writing a full account of this little-known group of islands.

The specimens so gathered were usually limited in number and quality by the very unfavorable conditions under which the men worked. At least in the southwest Pacific area most collecting was done in the settled lowlands, for the ousted enemy made the hinterland unsafe. Private Ted Bayer, an amateur zoologist who packed his delicate crinoids from Biak Island in available lichens to prevent breakage and thus unintentionally also became a plant collector, wrote from the Philippines, "We usually keep to open country for obvious reasons. I have seen no mosses in most localities."

Thus much of the material collected represents a widespread and technically less interesting flora. However, even this was poorly represented in American collections, and these specimens of common species will doubtless often be referred to because of our increasing scientific and commercial interest in these distant and formerly little-visited shores.

Unfavorable collecting conditions and inadequate equipment discouraged many. Lieutenant W. G. Adams, a botany teacher in private life, wrote, "My collecting urge is with me out here in a field that is rich beyond imagination. During the past ten months I have collected many specimens only to have them mold." So far as known, he never succeeded in sending any material home. The high humidity was almost universal in the tropical and subtropical areas, and few were those men who succeeded in drying their plants over artificial heat, which is practically essential in those regions. However, enough did succeed to prove that it can be done with ingenuity and perseverance, even under the restrictions of Army and Navy life.

Many field officers were cooperative and encouraged their subordinates in their efforts to engage in more enduring pastimes than poker and baseball. One collection was received with a captain's validity certificate stating that it was not obtained by theft or loot. Another officer personally transmitted a private collection to avoid difficulties with postal authorities. A major, a trained forester, undertook to initiate an interested corporal in forestry through plant collecting, even though the corporal, a former cowboy, was as much at home in the jungles as a "cow on skates." Several collectors acquired close companions who, though never having previously heard of scientific collecting nor studied biology, have become ardent addicts and are now on their way to becoming professional, or at least high-grade amateur, biologists. Thus the enthusiasm spread.

Some officers, however, could not comprehend such values, frowned on this "unmanly" pursuit, and forbade the shipment of collections. More often, stifled ambition resulted from indifference and lack of knowledge of procedure rather than from outright opposition. Sometimes discouragement came from the long delay between the dispatch of collections and the receipt of reports from the scientists concerning them, a delay due not only to the slow mails but to inexperienced and overworked specialists. One specialist, Dr. E. D. Merrill, of Harvard University, took great care, however, to report determinations within 24 hours, his long familiarity with tropical flora and his commanding position in the botanical field making this possible.

Although statements were issued in 1944 by both the Army and the Navy notifying postal authorities that dried and pressed plants were specifically exempt from U. S. Department of Agriculture quarantine restrictions, few officials were aware of them and, in order to play safe, refused to accept packages of plant specimens. This was a hard blow to many ambitious collectors, who had labored hard only to be forced to discard their collections. A private in Greenland abandoned several bundles when transferred, and a colonel in the Pacific was unable to mail a specimen he wanted identified. Mimeographed copies of these regulations were eventually prepared and mailed to correspondents, although unfortunately rather late in the program. Pharmacist's Mate Knox, on receiving a copy, replied:

> I was most interested in the memo. It often helps to point to black-and-white instructions. With the aid of the serial number I was able to find the circular in the Navy Department Bulletin, but probably never would have otherwise, since there are two large volumes of them issued every year.

Organized encouragement of this activity existed in a few places in the services but has not been as widespread as it could be. It was my happy experience to find the Washington offices of the Army and Navy interested in scientific, educational, and welfare activities, especially the medical branches, willing and eager to cooperate with this program. The hugeness and the complexities of the Army and Navy organizations and the preoccupation of those in higher authority with more vital matters, however, too often stifled the good intentions of those in the lower ranks. Perhaps the welfare and educational organizations of the Army and Navy cannot include in their programs an avocation which will appeal to such a numerical minority as the biologists. This constructive and beneficial occupation might well be fostered, it seems to me, whenever it springs up naturally. The Army and Navy might take a lesson from the Guam Society of Natural Science, organized on that island by a few interested officers and men when conditions became relatively stable. The military government responded to requests for assistance by sending out announcements of meetings and cooperated in other encouraging ways. Weekly meetings were held in Agaña, lists of interested participants distributed, and scientific collecting stimulated. A wide range of talents was represented, and at one time up to a hundred persons attended the meetings. The Society also included some natives well informed on the island's plants and animals. With the permanence and stability a continuing welfare organization could give, the Guam Society of Natural Science could be of great value to many bored servicemen and to the institutions to which their collections may be sent.

One of the greatest difficulties of those at home who were interested in this source of material was in finding organized channels through which they could work. This is by no means all in the past, for our present army of occupation, consisting of many thousands of men scattered through the East, contains young biologists eager to respond to a little encouragement and guidance; and the need exists for organizing this resource for the benefit of the services and of science. Some slight interest has been shown by those engaged in educational work among the occupying troops, but so far as is known this educational opportunity has not been exploited. It is suspected that few of those engaged in such teaching are willing to expose their lack of knowledge of the organisms about them and have neither the time nor means to fill in the gap. Also, most of them, like their predecessors, have failed to comprehend the potentialities of scientific collecting and the need for more material.

Considering the vastness of the opportunity and the number of biologically-minded men and women in the service, the actual number of specimens gathered to date is somewhat disappointing. Few people know there is any need for scientific material or what constitutes a specimen or how to prepare it. It was surprising to one familiar with herbarium specimens to find that almost no one, not even college graduates in botany, had ever prepared a specimen and that many had never even seen them. The significance, use, and preparation of specimens is not taught in beginning courses in this country, although most European scientists learn this in the secondary schools. Many of the servicemen never even suspected that there were places where they could get information on the plants and animals about them. This, it seems to me, is most unfortunate, for specimen collecting and identifying is a means whereby those who have had beginning courses in botany and zoology can most readily continue their contacts

and education in these fields when they take up other pursuits. The elements of scientific collecting should be taught in beginning biology courses to give a continuing perspective and an opportunity for further biological contact to those who do not go on with more advanced work.

Lieutenant Wagner, writing of the wide interest in natural science says:

> Some of the hobbies of servicemen were of such potential scientific value it is regrettable that previous training had failed to equip them to turn spare-time efforts into scientific accomplishments. Thus in the Solomons a man made an enormous collection of Lepidoptera with intentions of studying the group. Unfortunately he kept no records and neglected the smaller, less brightly colored species which are often the rarest and least known. . . . These hobbies could provide much knowledge of the biota of little-known tropical lands.

It was a great disappointment that an ecologist with a Ph.D. degree failed to collect a single specimen on Guadalcanal, although he studied and photographed many plant formations in his spare time. A forester with the same degree said he had never made a plant specimen "because in New England the few forest trees are easily learned in field courses."

In spite of these shortcomings of servicemen's collections, many valuable specimens have been received. Because of the nature of taxonomic work, it is rarely possible to determine very soon after receipt of a collection what novelties or new species it contains, for it usually takes some years for a collection to be thoroughly studied by experts. Especially is this true for collections from the Southwestern and Western Pacific and the Far East. We know much more about the novelties in the servicemen's collections from the Aleutians, for, although no American botanists have as yet completed a manual of the flora of Alaska, they know much more about these plants and have been eager to study the collections from there. A new species of lupine has been described from a collection stuffed in a pack by E. D. McDonald while hunting for Japs on Kiska. Many new records of higher plants for Attu Island were made from servicemen's collections, and there will be many of mosses, liverworts, and lichens, which lowly plants have been previously little collected there. It is confidently expected that the studies of future years will reveal a rich harvest of new species, records, and valuable information of other kinds from these collections.

The value of the collections brought or sent back by these servicemen collectors will be partly lost by their being scattered throughout the country. Attempts are being made to list these collections, but many valuable finds will be stowed away and forgotten in attics at home or stored in some institution where they are neither properly appreciated nor adequately cared for. Specimens from Spanish-American war veterans and their descendants are still drifting into the larger museums, but often the accompanying data have been lost and the specimens thus rendered useless. Partly for this reason efforts were made in the servicemen's collecting program to encourage the sending of collections to the larger public institutions, from which duplicates and superfluous material will be distributed to others in this country.

Besides the hobby-inspired collections of servicemen, many thousands of specimens were collected by trained personnel engaged in special Army and Navy surveys. The specialists of Navy Medical Research Unit No. 2 collected thousands of plants and animals in Guam, helping to make the biota of that island now fairly well known, as well as solving some epidemiological problems. An entomologist in malaria control work on Okinawa made an extensive botanical as well as entomological collection. The United States of America Typhus Commission, in its search for the causes of the occur-

rence and spread of scrub typhus in Burma, made carefully documented collections of plants and of potential animal vectors. Full sets of these specimens are deposited in public institutions where they will be permanently available for reference. They have as yet for the most part been only superficially worked over and will continue to yield knowledge for years.

An unmeasurable by-product of this collecting were the many pleasant contacts between servicemen and local people with like interests. Major Lambert learned much about Philippine timber trees from native foresters and urged continued contact between them and interested American botanists. Private Jack R. McMillen, an ardent orchid hunter, with the U. S. Army in Burma, twice visited Dr. K. Biswas, the director of the Royal Botanic Garden near Calcutta, India, and sent or took most of his specimens there for identification and for subsequent division with the U. S. National Herbarium. Dr. Biswas wrote to me after this visit what a pleasure it was to meet an American botanist from the Army and expressed his hope that the officers would encourage their men to use this means of learning of their natural surroundings and of meeting the cultured Indians. The officers concerned with supplying food for the army of occupation in Japan through extensive hydroponic projects are working with Japanese botanists to mutual advantage.

THE personal experiences of the numerous biologists, as shown in their letters and notes, shed much light on the successes and failures of scientific collecting by men engaged in war. A few extracts from my files, in addition to the quotations already given, will reveal what a rich experience plant collecting has been.

Lieutenant Wagner, already quoted, writes in addition:

> You would be amused to see me hitchhiking on jeeps in advance areas, hiking up hill and down valleys looking for monitors, laughing jackasses (the kingfishers), geckos, and new sights in the world of nature. I have come across whole bodies while brushing through the woods on many hurried trips, but when you expect such things they don't jar you a bit. It is incongruous, though, to see evidence of such violence while engaged in the gentle and innocuous sport of botanizing. I have learned a lot about Pacific vegetation and have secured some fine specimens of Pacific rarities. My pteridophyte collection, made jointly with D. F. Grether [no biologist at all before he teamed up with Lieutenant Wagner] now totals over 700 collections. I am trying to get together a fern flora of Guam. Many species of pteridophytes have been reported from Guam by various authors since 1902. Grether and I are now able to evaluate their frequent erroneous records in the light of our large collections and the observations of numerous field trips. There are now 55 species known from there, of which 8 have never before been recorded. The results of our collections in the Admiralties are even more striking, the known number of species now being 165, whereas, so far as we can discover, only 39 had been reported earlier. We expect in the near future to publish papers on the pteridophytes of this group also, based on our "extra-curricular" studies while in the service.[2]

Among the most ardent and capable of the writer's collector correspondents was Lieutenant George B. Van Schaack, USNR, stationed on Attu Island at the western end of the Aleutian chain. He was a college mathematics teacher and amateur botanist before the war, entirely unacquainted with collecting. To me he wrote, in part, as follows:

> Making a collection of plants was probably one of the last things any serviceman ordered to duty in the Aleutian Islands expected to do. The islands had been played up so prominently as completely desolate that it is doubtful if any of us expected to see so much as a blade of grass. It is perhaps because of this very fact that, when the full beauty of the summer vegetation there burst upon us, so many found an interest in the flowers who, back home, had taken the summer greenery and bloom for granted. Privates and majors, seaman and captains, were then to be found picking flowers and either send-

[2] Lt. Wagner has told about his "Fern Hunt in Puerto Rico" while flying for the Navy in the Caribbean region in the *American Fern Journal*, 35, (1), 1945, 4–9, illus.

ing them home in cellophane wrappings via air mail or pressing them in magazines to take home when the long-looked-for day of leave should come. A few of us, having a slight knowledge of the scientific importance of accurate and complete data on the flora of a region, and realizing the probable paucity of such information for the Aleutians, went further and attempted to make large collections of scientific significance. Important collections of this type were made at Dutch Harbor, Atka, Adak, Amchitka and Kiska, but, so far as I know, the largest and most complete collections were made on Attu Island, the most remote member of the Aleutian chain.

Altogether, these collections total between three and four thousand numbers and between three and four hundred species. This makes possible a fairly wide distribution of specimens, and the interests of the several collectors are such that a number of different institutions will benefit.

It is unlikely that many of the persons who found such interest in the flowers of Attu would care to return to the island under any circumstances. But I feel sure that all of them will, in varying degrees, remember their exile on Attu with less bitterness for having had that interest.

Captain L. T. Burcham, First Marine Division, before the war was a Range Examiner with the U. S. Department of the Interior, affectionately dubbed in Western states a "grass counter." Unlike most of the collectors before mentioned, he was well versed in botany and plant collecting, especially of grasses, before entering the service and needed no serviceman's collecting program to stir him to "make hay." Following are two extracts from an assemblage of botanical notes which he gathered from his letters home for my use in preparing this article. His delightful descriptions of the vegetation and of the striking plants and animals he found will be published in full in a subsequent issue of THE SCIENTIFIC MONTHLY.

From Guadalcanal in December 1942 he says:

My well-laid plans for collecting grasses in New Zealand have gone sadly awry. On a few hours' notice I found myself boarding a plane. There have been compensations; I have started gathering specimens of the local grasses. Even the problem of securing plant driers has been unexpectedly solved for me. I had to leave all mine behind because of weight limitations on baggage and naturally had anticipated difficulty in obtaining any material suitable for drying plants. However, within a day or so of arrival we received a shipment of aerial photographs, which had been printed and dispatched to us while wet, packed between sheets of heavy blotting paper. These I carefully salvaged, dried in the sun, and am now using them in drying specimens. Interestingly enough, my collections are faintly reminiscent of ancient history, for among the first lot of grasses was one known as jungle rice (*Echinochloa colonum*). Husks from the grains of this grass have been found in the stomachs of mummies taken from some of the earliest graves in the Nile Valley. It is not now cultivated.

After being in the Palau operation and spending a day on the undevastated eastern side of Peleliu Island, he wrote:

That trip gave me an opportunity to look at the vegetation of these small, sandy coral islets. I've collected some specimens of the grasses and will continue as soon as this rainy spell lets up. My plant press here is the pages of a Jap military manual that was printed on newsprint! A trifle small, but it suffices.

Few want to remember the military experiences of World War II, but few will forget the lighter hours given to natural science. The equipment for war is being destroyed, but the scientific specimens are being preserved. The opportunities for productive scientific enterprise by the occupying forces are still available. Will they be seized upon or wasted? Those in need of scientific collections are still ready to send aid and encouragement to any likely collector or possible future biologist.

EARLY CHINESE JADE

By A. G. WENLEY

DIRECTOR, FREER GALLERY OF ART

THE term jade is properly used to designate two particular types of ornamental stone, known respectively as nephrite and jadeite.

Chemically, nephrite is a silicate of calcium and magnesium, $CaMg_3(SiO_3)_4$, and is a mineral of the amphibole group. It is of a tough, compact, fibrous structure, so finely grained that magnification is necessary to observe it The fibers of which it is composed may be arranged parallel to each other, curved, twisted, interlocked, or felted, perhaps superficially resembling more than anything a tremendously compressed asbestos. According to Moh's scale, it has a hardness of from 6 to 6.5, and its specific gravity is from 2.96 to 3 1.

Jadeite, on the other hand, is one of the pyroxene group of minerals, the chemical composition being an aluminum sodium silicate, $NaAl(SiO_3)_2$. It has a hardness of from 6 to 7 and a specific gravity of from 3 3 to 3 5.

In contradistinction to nephrite, jadeite has a vitreous luster, being crystalline rather than fibrous in nature, giving it when polished a shiny appearance, whereas nephrite has a rather waxy appearance. To distinguish between these minerals, which so strongly resemble each other, microscopic examination and chemical analyses are necessary.

Another mineral which may be regarded as a variety of jadeite is chloromelanite, which contains large amounts of iron—as much as 10 percent—and varies in color from dark green to almost black.

Both nephrite and jadeite, in an absolutely pure form, should be white with no color. Actually, however, a variety of colors exists in these stones owing to the presence of other elements. For example, the green of jadeite may be due to the presence of chromium, while nephrite often contains small quantities of iron However, the Chinese term *yu*, which we generally translate as "jade," has been used through the ages to cover a wide variety of decorative stones capable of taking a soft, lustrous polish Of these, nephrite and jadeite of course are the ones to be considered as true jade, but from earliest times to the present day other, softer, materials, such as agalmatalite, bowenite, marble, and many others have been used for carving purposes. In color these stones range from black to white, with shades of yellow, russet, fawn, brown, gray, green, blue, and even purple in-between Thus it is impossible to make any differentiation by means of color alone. Hardness and specific-gravity tests are not conclusive, but occasionally they may enable one to tell fairly quickly whether or not a given stone comes within the range of nephrite, jadeite, or chloromelanite.

Both nephrite and jadeite seem to occur in a number of places throughout the world, and new discoveries of deposits of these minerals are made from time to time. To give a general idea of its distribution, we may say that nephrite, for example, has been discovered in Silesia and in the Alps in Europe. It also seems to occur in a number of the Pacific islands, including the south island of New Zealand, where it occurs in quantities, and also New Caledonia. A dark-green nephrite comes from Siberia, near Lake Baikal, and in Turkestan there are quarries in the Karakash and Yarkand river valleys from which a great deal of the nephrite

Freer Gallery of Art, No. 40.10
CEREMONIAL SICKLE
THE BLADE OF JADE AND HANDLE OF BRONZE ARE INLAID WITH TURQUOISE. .345 × .175 M. OVERALL. SHANG DYNASTY, 14TH-12TH CENTURY B.C.

used by the Chinese is taken. Jadeite is found chiefly in Burma around the tributaries of the Irrawaddy River in the North, and objects of jadeite are common in Mexico, Central America, and the northern part of South America. Jade seems not to have been known in the Western world until sometime in the sixteenth century, after the Spanish Conquest of Mexico, although it was actually known to our neolithic ancestors in Europe, where artifacts have been found in various neolithic sites, particularly in Switzerland. Thus our word jade is a late addition to our language, coming ultimately from the Spanish *piedra de ijada,* or "the stone of the side," since the stone was applied as a medicine for a pain in the side. The word nephrite also has a medical origin, coming from the Greek *nephrit,* the "kidney"; it was known as the "kidney stone" and used as a specific for kidney pains.

In China, however, jade appears to have been used literally for ages, that is to say, from mesolithic times, that period just between the Old and New Stone Ages, up to and including the present day. It is small wonder, then, that among the Chinese this stone has been revered as the mineral par excellence. Throughout Chinese literature all that is fine and good is compared with jade. Indeed, it has been said that the ancient Chinese considered it as the essence of power or virtue rather than simply as a precious stone, and the fact that they utilized even the smallest fragments of it shows in what great value it was held. Where we of the West might say "as pure as gold," the Chinese might say "as pure as jade." Comparable to our expression "a diamond in the rough" as referring to persons, an old Chinese adage says, "As an unpolished jade is an unfinished article, so a man without learning is without understanding." It is valued no less in modern times, and in 1889 a book known as the *Yü p'u lei pien* was published in four chapters giving references to jade from all branches of Chinese literature. The finest qualities of jade in China come either from Northern Burma or from Sinkiang, Chinese Turkestan. The rough article taken from quarries, or mines, is known as *shan liao,* or "mountain material." Pebbles or boulders of jade taken from river beds are known as *tzŭ yü,* or "seed jade."

Jade is a very hard stone, and the carving and cutting of it are very exacting, requiring much time and patience.

How the ancient jades of the Shang (*ca.* 1766–1122 B.C.) and Chou (*ca.* 1122–207 B.C.) dynasties were carved cannot be explained in any detail. Suffice it to say that from the discoveries made at the excavations at Anyang, in Honan, evidence has been found that the Chinese jade carver already was using a rotary blade for sawing, a pointed drill for drilling, and fine sand as an abrasive. However, we do know that by about 1400 B.C., the Chinese jade carver apparently had a perfect command of his tools and materials, as can be seen by the beautiful objects wrought at that time. It is also pertinent to note here that evidently the jade mineral used at that time was found somewhere in the districts near Anyang. This is extremely interesting, for up until this discovery we could not be absolutely sure where the ancient Chinese obtained their raw materials.

Freer Gallery of Art, Nos. 39.21 and 39 31

BLADE AND DAGGER HANDLE

Left: MINIATURE BLADE OF JADE. LENGTH .171 M. CHOU DYNASTY, CA. 5TH–3RD CENTURIES B.C. *Right:* CEREMONIAL DAGGER HANDLE OF JADE. LENGTH .178 M. FROM THE SHANG DYNASTY.

IN MODERN times, the carving of jade may be divided into several parts. To begin with, the rough stone is carefully studied, and plans drawn so that every part of it may be utilized. Next comes the job of dividing up or roughing out the stone to the general shape desired. If it be a large boulder, it is put under a large, swinging, soft-metal knife which is swung backwards and forwards, gradually sawing its way through the stone by means of water and an abrasive. Smaller stones or the stones derived from the larger blocks are then roughly shaped by being held against a primitive circular blade of soft metal. This is worked by pedals from which lines go to either side of the arbor, or axle, on which the disc is mounted, each line wrapping around the arbor in an opposite direction, so that when the pedal pressure is applied, the saw rotates six or more times in one direction and then six or more times in another. By feeding abrasives to the cutting surface, the saw gradually works its way through and the object is roughed out. From this rough sawing, the piece next goes to the carver, who utilizes a smaller disc blade and abrasive and also a diamond drill. Needless to say, the last and final careful carvings are done by only the most experienced of the carvers in the shop. The whole process is extremely time consuming and requires great skill and patience, although in recent times the use of carborundum as an abrasive and also the diamond drill has to some extent hastened the process. The last step in the whole procedure is polishing. For this, gourd fiber is widely used, and occasionally the product is given an acid bath. Finally paraffin is employed.

How far removed these modern processes are from those used in ancient times, it is impossible to know at present, although no doubt much of the old technique persists along with the more modern developments. It is to be hoped that the introduction of modern power-driven devices will not cheapen, or detract from, the works so beautifully done today.

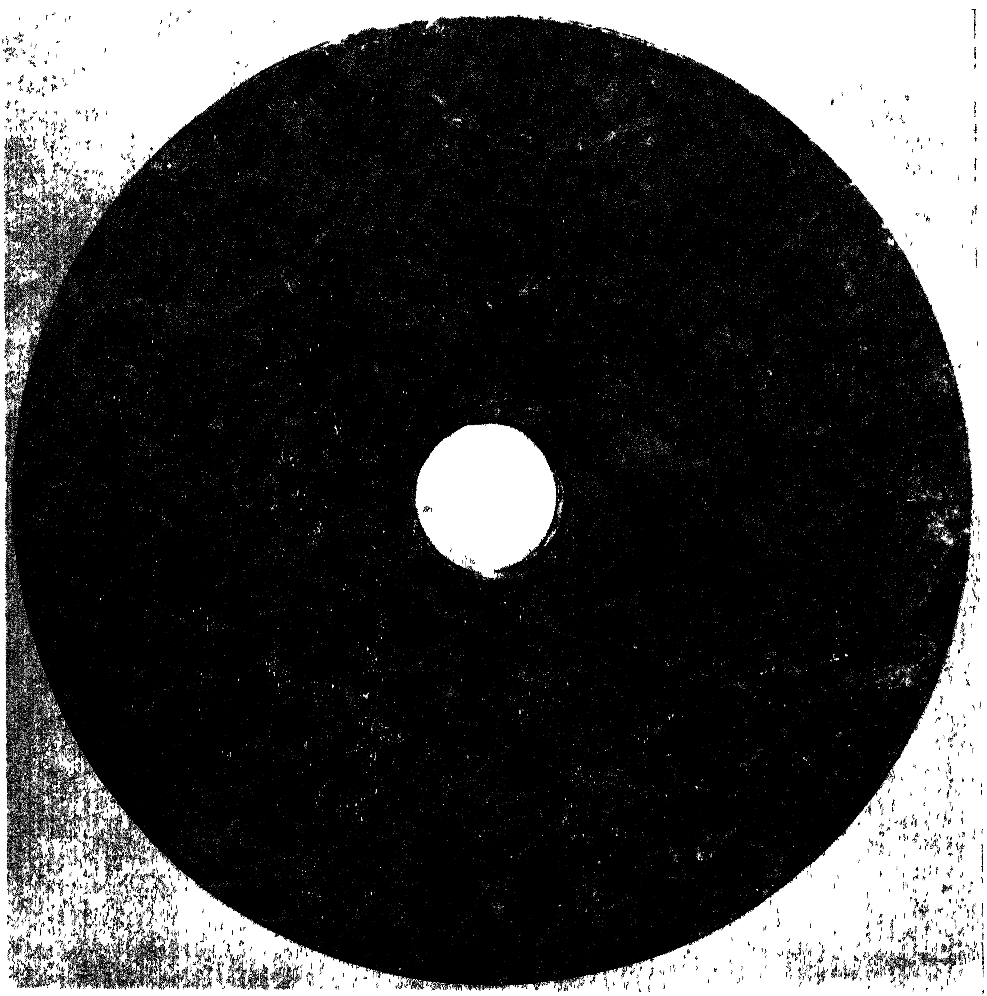
Among the really fine hard stones used to make various articles in ancient China, nephrite appears more generally than jadeite, and other varieties of stones, perhaps anciently mistaken for nephrite, also appear in some quantity. These were manufactured into objects of a variety of shapes and decorations. We know, as yet, comparatively little of the early Chinese culture which produced these objects, but it is safe to say that the broad basis of early Chinese civilization was agricultural and that religion was, in general, animistic, or concerned with nature worship. Added to this was the necessity of protecting agricultural holdings from intrusions of other peoples and the extension of such holdings by means of excursions against bordering peoples. This necessitated some sort of military establishment. We have, therefore, three essential factors on which the conduct of the community was based—agriculture, religion, and war. These, it seems fair to suppose, gave rise to the forms of implements connected with governmental and religious ceremony, and these two were naturally very much intermingled; hence, many of the jade forms no doubt represent either military or agricultural implements made to be used for civil or religious ceremonial purposes. We may thus divide these objects into four general types: religious symbols, badges of office, funerary offerings for the dead, and ornamental objects.

Attempts have been made to identify the various jade forms with the descriptions appearing in early Chinese texts. While such identifications are by no means certain, we use the following list for the general idea it gives today as to the use and importance of jade in early Chinese culture. Under the first heading, religious symbols, we have: (1) a perforated disc, called *pi*, sometimes called the symbol of the deity Heaven; (2) the squared hollow cylinder *ts'ung*, sometimes called the symbol of the deity Earth; (3) the "ring" *pi, huan*, sometimes called the symbol of the deity North; (4) the green tablet *kuei*, sometimes called the symbol of the deity East; (5) the red tablet "half-*kuei*," *chang*, sometimes called the symbol of the deity South; (6) the tiger tablet *hu*, sometimes called the symbol of the deity West; (7) rings, flat or round, used as offerings.

Under the second heading, badges of office, we have blades, tablets, and certain forms resembling axheads, chisels, scrapers, etc., some of which seem to have been derived from earlier Stone-Age weapons and tools and to have survived as objects of ritual, carried or worn by persons as emblematic of their official rank.

Under the third heading, funerary offerings, we may include any of the above items, also various amulets to be placed on or in various openings of the corpse such as the mouth and eyes, as well as garment ornaments of one sort or another. It is worthy of note here that many of these funerary offerings apparently were placed in the grave purposely in an unfinished condition. Thus we may find, for example, a jade halberd, beautifully carved on one side but unfinished on the reverse.

Under the heading ornamental objects, we have necklaces, headdress ornaments, girdles, and dress ornaments; fittings for swords, scabbards, and weapons of various kinds; tallies and seals; carvings of animals, fishes, birds,



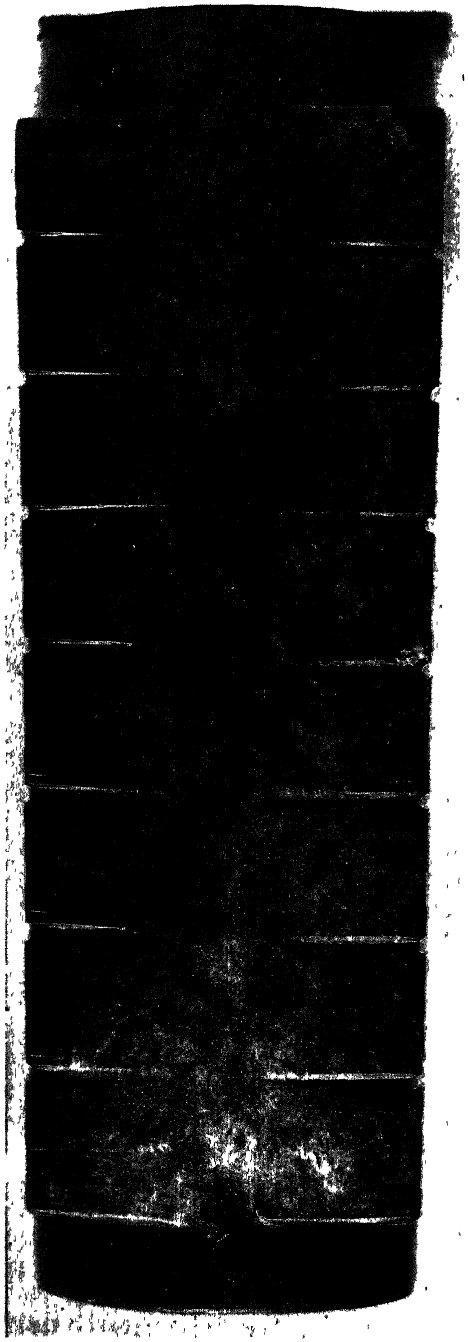
Freer Gallery of Art, No. 19 85

PERFORATED JADE DISC *PI*

A SYMBOL OF THE DEITY HEAVEN. DIAM. .226 M. CHOU DYNASTY, FIFTH–THIRD CENTURIES B.C.

monsters, and insects. All these, however, may also be indicative of rank, or they may be offerings or gifts of one kind or another. Aside from their shape, the ornamentation of these objects, often done with incredible skill, includes line engravings, relief carving, or countersunk relief carvings; and sometimes all three are present on one object. As for patterns, there are linear arrangements, such as fillets and zigzag lines, both simple and interlaced, forming lozenges and scrolls of various kinds, including the so-called thunder-and-cloud scrolls. Animalistic designs are monster forms, the dragon, the cicada, etc. A serrated edge ornamentation of silhouette characters is peculiar to early Chinese jades and cannot be explained. There is also the grain pattern, which is composed of tiny bosses.

In addition to the above uses for jade, we must not forget that this ornamental stone has always been used for many



Freer Gallery of Art, No. 18.14
SQUARED HOLLOW CYLINDER
Ts'ung SYMBOL OF DEITY EARTH. 207 × .069 M.
THE CHOU DYNASTY, 5TH–3RD CENTURIES B.C.

utensils of various kinds: cups, bowls, pots, dishes, seals, writing-brush handles, musical stones, and even flutes of jade. Also we find various objects of jade used for room decorations: jade carved in figures, jade carved as landscapes, jade slabs engraved with poems, jade carved as fruit and flowers, besides images of Gods and Worthies of Chinese mythology.

Today, the main value of these objects is in the quality of the material and the excellence of the workmanship, and it follows that usually the finest workmanship is found upon the best material. However, it must not be forgotten that jade deteriorates in burial, and some of the early jades we have today which perhaps once were nephrite, have changed chemically through the action of the soil and the passage of years. It is this decomposition of materials which makes specific-gravity and hardness tests virtually worthless when dealing with certain of our archaic jades.

This is borne out by specific-gravity tests made recently upon the jade collection at the Freer Gallery of Art. Tests of 32 of the Shang dynasty pieces showed that 17 were below the specific gravity of nephrite. Of these 17, 9 displayed a considerable state of decomposition or had earthy incrustations or other foreign matter adhering to them. These probably were all nephrite in their original state. The 8 pieces left were either definitely of other material in the beginning or were completely disintegrated, and the change had been so serious that it was impossible to say what the original stone might have been. In a group of 217 Chou dynasty stones weighed, 131 proved to be below the weight for nephrite specific gravity. But here again a great many of these were badly decomposed or had earthy adhesions or other foreign matter on them which affected the reading of the true specific gravity. As a qualitative study, we may take then

just the 15 Shang nephrites and the 86 Chou nephrites which stood the specific-gravity tests. Of the Shang nephrites, 13 are large ceremonial implements and weapons of fine quality material, with strong lines and finished workmanship. There is very little decomposition in these. Three smaller decorated pieces of light, translucent material have been well handled in composition and design. Fifty-four of the early Chou pieces comprise mostly undecorated *pi* or *ts'ung,* with the regulation designs, and plain *kuei* of various forms. The *pi* and the *ts'ung* are mostly of dark, closely mottled, varicolored materials with little or no translucence and with a strong tendency toward white decomposition, especially in the veins. The *kuei* are usually a solid color or two-tone, with little or no decomposition. Thirty-two late Chou pieces show a decided change in material and decoration. The 6 *pi* are translucent and mostly of light colors. All are decorated with the "grain" pattern in relief and incised. The remaining pieces, cups, rings, ornaments, and jewelry, are of light, translucent material with a tendency toward a cloudy white, or milky, opaque surface alteration. They all have the superb workmanship and design characteristic of this period, which is unsurpassed before or since. If we speak of the value of these jades in the terms of intrinsic value, there is obviously only one value, and that is "scarcity" value. This, in turn, depends upon the condition of the market and the circumstances surrounding the acquisition or sale of such things. Market values, furthermore, may fluctuate to a greater degree even than those of our stock market. The true value is that of quality; quality in conception, execution, and materials, and that is a great moral lesson which may apply to everything made in this world. The aesthetic appeal of jade exists in China to the present day. It is valued not only for its beauty as a stone that appeals to the eye, but equally for its appeal to the touch. As we have seen, it is extremely hard and very difficult to work, and the fact that we have both extremely simple and highly ornamented objects of this material dating from very early times is an indication of its two-fold appeal.

Freer Gallery of Art, No. 30.27

AN ELABORATE NECKLACE

CONSISTING OF FOUR STRANDS OF BRAIDED GOLD WIRE, WITH TEN JADE OBJECTS ATTACHED TO IT. LENGTH IS .407 M. FROM THE CHOU DYNASTY.

JAMES SMITHSON

"My name shall live," he said, "my name shall live
In the memory of man when vain titles
Are forgotten. But who am I to boast?
You ask me my name. Well, I will tell you . . .

"My father was the most high, puissant,
And noble prince Hugh Percy (born Hugh Smithson),
The Earl and first Duke of Northumberland,
Earl Percy, Baron Warkworth and Lovaine,
Lord Lieutenant and Custos Rotulorum
Of Middlesex and Northumberland Counties
And of all America, and a Lord
Of His Majesty's most Honorable
And Privy Council and Knight of the most
Noble Order of the Garter, et cetera—
One of the handsomest men in all England.
And my mother? Elizabeth Keate Macie,
The heiress of the Hungerfords of Studley,
A widow, and descended from a King . . .
The best blood of England flows in my veins,
Yet this avails me not. But who am I?
I am James Lewis Macie, or James Smithson,
A commoner, born in France out of wedlock,
Master of Arts from Pembroke College, Oxford,
Fellow of the Royal Society.

"Yes, once I thrilled at the great name of Percy:
Like Sidney, two hundred years ago now,
'I never heard the ancient song of Percy
And Douglas that I found not my heart moved
More than with a trumpet.' Save for a marriage
I'd be a Percy too I've felt it keen,
But think me not bitter about it now—
That was long ago. Now I'm getting on:
I am sixty-one and must think of death;
I am lonely and ill; there's not much left
For me—two, or three, or four years, perhaps . . .

"No ignorance is without loss to man,
No error without evil, and therefore
I have loved truth and have dabbled in science;
That has been my pleasure, and it may be
(Who knows?) I have enlarged those lurid specks
In the vast field of darkness. But also
I have loved fame, that 'last infirmity
Of noble mind.' 'Fame is the spur,' said Milton
Now by this earth's wealth which has come to me
I vow to make it true as I have dreamed:
The name of Smithson shall be linked with truth
And with the spread of knowledge through the world,
For ignorance has been my enemy
As it is all mankind's."

So having said,
With deliberate speech and firm countenance,
He took up his pen and began to write
These bare words:

"I, James Smithson, son to Hugh
And Elizabeth . . . this twenty-third day
Of October, year eighteen twenty-six,
Do make this my last will and testament . .
And I bequeath . . . to the United States
Of America all my property
To found at Washington an Institution . . ."

So was his duty done, his dream reborn.
"I shall not altogether die," he said;
"Smithson shall live when Percys are extinct,
Until the world at last shall know the truth
And be forever free."

PAUL H. OEHSER

A BRIEF HISTORY OF THE ZOO

By WILLIAM MANN

DIRECTOR, NATIONAL ZOOLOGICAL PARK

"The House did not report the same."

This is from the report of the Secretary of the Smithsonian Institution for the year ended June 30, 1889. "The same" was a request for $5,000 for the care and maintenance of the United States National Museum's department of living animals, of which William T. Hornaday was curator. The animals had come in as gifts to the government, and their number was increased during the following year by a trio of American elk sent by the Honorable W. F. Cody (better known as Buffalo Bill), of North Platte, Neb., 4 American bison from Dr. McGillycuddy of Rapid City, Dak., and gifts from various United States Army officers stationed in Texas.

Animals were accepted reluctantly. There was little place to keep them, and most of them were in an overcrowded, steam-heated temporary building, filled during visiting hours with enough sightseers to make it uncomfortable. There was no appropriation wherewith to buy feed for the animals, and the limited funds of the Smithsonian had to be used. Some of the animals served as models for the taxidermists who were mounting North American animals for the National Museum and were afterward sent to the zoological gardens already established at Philadelphia or Cincinnati or to the New York Central Park menagerie.

The previous year, 1888, Senator Beck of Kentucky had brought before the Senate a bill for the formation of a zoological park. This did not pass. In 1889 a bill sponsored by Senator Edmond was passed for the establishment of a National Zoological Park in the District of Columbia for "the advancement of science and the instruction and recreation of the people," and $200,000 was appropriated to purchase and improve the site for the Zoo. A commission consisting of three persons was appointed: The Secretary of the Interior, the President of the Board of Commissioners of the District of Columbia, and the Secretary of the Smithsonian Institution.

This committee selected the site of the present Zoo,

> . . . . a site in the picturesque valley of Rock Creek, in the portion nearest the city. Here not only the wild goats, the mountain sheep and their congeners would find rocky cliffs which are their natural home, but the beavers brooks in which to build their dams; the buffalo places of seclusion in which to breed, and replenish their dying race, aquatic birds and beasts their native homes, and in general all animals would be provided for on a site almost incomparably better than any now used for this purpose in any capital in the world (Letter from Secretary Langley to Congressman Samuel Dibble).

Largely featured in correspondence concerning the Park at that time was the preservation of North American animals on the verge of becoming extinct, especially the bison.

Mr. Hornaday resigned at the end of the year, and Dr. Frank Baker, honorary curator in the Department of Comparative Anatomy at the National Museum, was appointed as "Acting Manager" of the Park. Mr. W. H. Blackburne, of the animal department of the Barnum and Bailey Circus, was put in charge of the animals; he was given the title of Principal Keeper. He stayed 53 years and is still consultant to the Director.

A bridge was put over Rock Creek; destroyed by a freshet the following year, it was rebuilt immediately. Roads were made. In 1892 there was a deficiency appropriation of $1,000 for the care and subsistence of animals, half to

be paid by the treasury of the District of Columbia and half to come from the Treasury of the United States. The annual report for that year gave the first census of the collection of 406 specimens.

A firm of landscape architects, Olmsted and Eliot, was engaged to plan improvements in the Park, and land was added, a few acres at a time, purchased from different owners. Mr. H P. Waggaman made a gift of over an acre. The road at the entrance was graded to make it practicable for carriages, the Zoo at that time being "a pleasant carriage ride from the city." Editorials proclaiming the undoubted future greatness of the Zoo appeared in leading papers throughout the United States.

During the first year a buffalo cow, annoyed by a visitor, broke through the fence and charged at a nursemaid, who diverted it from the baby she was tending; a brave spirit spat tobacco juice in a bear's eye and was fined $5.00; an editorial appeared in a Washington paper decrying "saddling cost of Zoo on District"; one front-page cartoon showed the District of Columbia as a small boy with a patch on the seat of his pants, threatened by the Appropriations Committee in the form of an Italian organ-grinder carrying a monkey labeled the "National Zoological Park." He held a knife, the "Appropriations Snickersnee," ready to drive into the lad, and the legend ran: "Adrone Giuseppe Cannoni to the District—'Gimma da Mon to Feeda da Monk or I cutta da Troat.' "

The Quincy, Ill., *Herald* stated in an editorial that the Zoo "will soon be a credit to the Nation, but should be paid for by the Nation and not by the District." Editorials in other papers discussed the rapacity of the Washingtonians unwilling to pay the costs of a Zoo for their own benefit. After 56 years

AMERICAN BISON
ONE OF THE REASONS FOR ESTABLISHMENT OF THE NATIONAL ZOOLOGICAL PARK.

the subject is still brought up annually. One may state now that on big days at the Zoo there are cars from every state in the Union and one or two cars also from Alaska, Canada, the Canal Zone, Hawaii, and Puerto Rico.

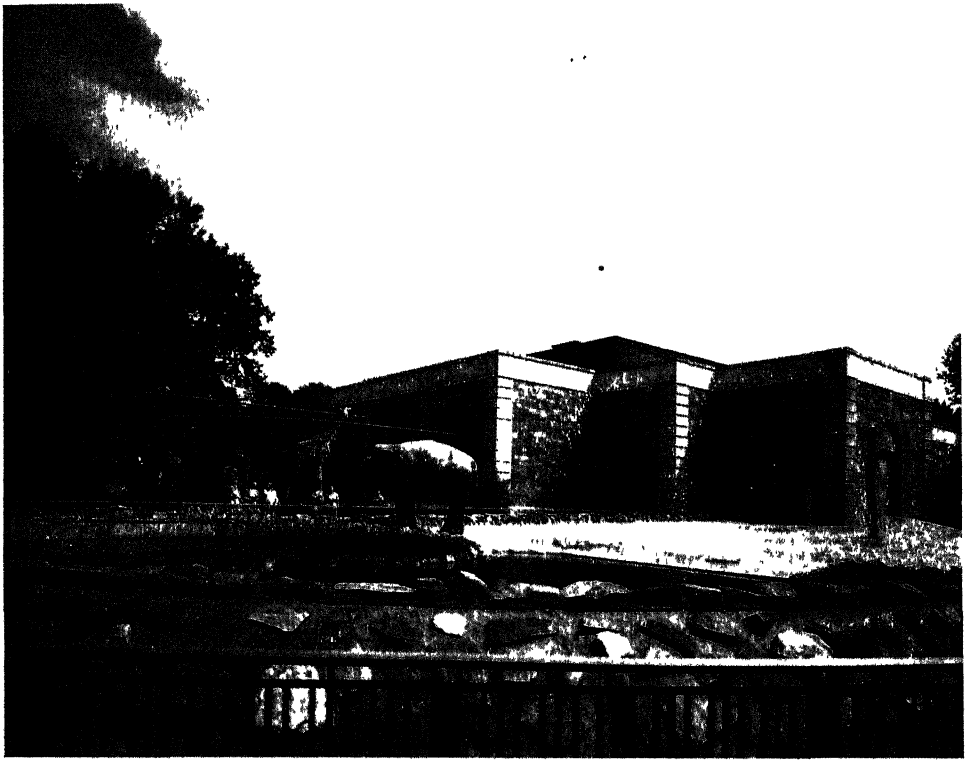
IN THE early days there was no money to buy animals, but some funds were available to collect them. An unsuccessful expedition was made to Alaska to secure the large brown bears. Then, by permission of the Secretaries of State, War, and the Navy, the Zoo sent a circular to officials abroad requesting animals and giving instructions for their care and shipping. The results were surprisingly good. The Governor of Pará sent a large shipment, and Commander Todd of the U. S. S. *Wilmington* brought from Brazil 18 animals, including a tapir and the very rare harpy eagle. Alexander Graham Bell brought mandarin ducks from the Zoo in Tokyo, Japan. Yellowstone Park contributed elk and deer, and the superintendent there thought it would be possible to catch a grizzly bear. Accordingly, a trap was made at the Zoo and shipped to the park, and a grizzly was caught. Two raccoons were captured in Rock Creek Park, and the President of the United States presented an opossum, probably a wild one from the White House grounds. Eight black squirrels came from the Toronto Park Department and were liberated. There are now dozens of these thriving in the Park.

F. W. Goding, of Newcastle, New South Wales, sent an assortment of 140 specimens, including echidna, flying phalangers, a Tasmanian wolf, a Tasmanian devil, and 30 parrots and cockatoos, following this shipment the next year with 15 specimens, including a mate for the Tasmanian wolf.

The U. S. Fish Commission ship, *The Albatross*, brought an even dozen of elephant tortoises from the Galapagos. After the Spanish-American War, the Army sent various lots of specimens, including an amazing shipment of 15 Cuban crocodiles (*C. acutus*). At the present time a single specimen of this

Photo by W. R. Schufelt

THE FIRST ELEPHANT HOUSE



EXTERIOR OF THE NEW LARGE MAMMAL HOUSE

crocodile in captivity is unique outside of Cuba.

James E. Cooper, owner of the Adam Forepaugh Shows, presented a pair of elephants, Dunk and Gold Dust. Gold Dust soon died, but Dunk remained a popular figure in the Zoo for more than a quarter of a century. Many years later, Ringling Brothers Barnum and Bailey Circus presented Babe, one of their historic elephants.

In 1893 many animals of the Forepaugh Show were deposited for the winter in the Park; some arrived in circus menagerie wagons and were quartered with dromedaries, zebus, and llamas in a temporary stable. The Zoo was to receive half the animals born during the winter, and the net result was one baby kangaroo. However, it is interesting to know that the only hairy-eared Sumatran rhinoceros ever exhibited here was lent by the circus and represented this species for the first and last time in Washington, and perhaps in America.

The King of Abyssinia presented President Theodore Roosevelt with some gelada baboons, a lion, and a Somali ostrich; the ostrich lived for 26 years. An exchange was made with the New Zealand government, and a kiwi and a tuatara lizard were put on exhibition. The following year Ras Makonnen, the Governor of Harrar Province in Abyssinia, sent zebras and lions; the Swiss government sent 5 chamois; and W. M. McMillan, of Nairobi, East Africa, offered such a sizable collection that the Assistant Director of the Zoo, Mr. A. B. Baker, journeyed out there and brought back lions, cheetahs, leopards, gazelles, and wart hogs as gifts and a considerable

number of smaller species that he collected himself.

By 1895 the Zoo's collection was so well established that 13 animals were loaned to the Adam Forepaugh Shows, probably in return for their previous gifts of 2 elephants.

By 1910 there was an average of more than 1,400 visitors a day in the Zoo.

Secretary Langley was fond of coming to the Zoo, where he not only was able to get away from crowds, but also, on a platform built in an oak tree in the Park, to observe the flight of vultures and other birds; afterward he would make his calculations in a quiet room in the Zoo offices. Thus the Zoological Park is closely associated with the early studies of aeronautics in America.

In the early days of the Park the Appropriations Committee of Congress seemed to have a habit of doing things by halves: $35,000 was asked for maintenance, and $17,500 was appropriated; $36,000 for improvements was cut to $18,000; and when $20,000 was begged in order to build an elephant house, $10,000 was granted. This did not build a very large elephant house, but it served for 35 years, when it was replaced by a $287,-000 pachyderm house.

In 1913 the government zoological gardens at Giza, Egypt, offered a collection of interesting things, and Mr. Blackburne sailed to get them. He brought back a pair of African elephants, cheetahs, 3 dromedaries, and several other specimens. Jumbo II, as the male elephant was named, died after 3 years, but the other, Jumbina, is still living. Moving her from the quarters she had occupied for nearly a quarter of a century to the new pachyderm house, in 1937, was a formidable task. A strong crate was built, and the elephant, once inside it, was hauled up on a low flat truck to make

EXTERIOR OF THE BIRD HOUSE

EAGLES LIVE IN NATURAL SURROUNDINGS

the move. Since then Jumbina continues to look with disfavor on the Zoo's boss mechanic, whom she evidently associates with certain indignities connected with the ride.

In 1916 the Duke of Bedford sent Kashmir deer and eland, and the Canadian government some Rocky Mountain sheep.

In 1917 Dr. Frank Baker resigned after 26 years of service, and his place was taken by Ned Hollister, of the Biological Survey. At this time Mrs. Charles D. Walcott, wife of the Secretary of the Smithsonian, campaigned among her friends in the city and raised enough money to buy a pair of Sumatran elephants, Hittam and Kechil. Kechil is still living, but Hittam died many years ago. F. W. Goding, who had sent the Australian collection, turned up again, this time as consul at Guayaquil, and sent some Galapagos tortoises.

Other friends and Zoo fans continued to donate specimens; some of them—for instance, Captain Kellers, of the U. S. Navy, and Victor J. Evans, of Washington, D. C.—were steady contributors year after year, and these contributions, with funds at last available to purchase animals, steadily improved the collection.

Under the auspices of Austin H. Clark, of the National Museum, a series of 31 radio talks was given in 1926, through the cooperation of Station WRC, and each talk included a brief statement of current news at the Park, usually by the Director, who then introduced the speaker of the evening.

Ned Hollister died in 1924, after 8 years as an able superintendent of the park, and was succeeded by Dr. Alex-

ander Wetmore, who served for 5 months, when he was appointed Assistant Secretary of the Smithsonian. He was followed by the writer, in 1925.

THE following year was a momentous one. Walter P. Chrysler, taking an interest in the Zoo, financed the first expedition that had been possible since those of the very early days of the Park. A group of four collectors went to Tanganyika, East Africa, returning after seven months in the field with over 1,600 specimens, including a pair of giraffes, the first ever in the Zoo, 30 antelopes, leopards, wart hogs, and much smaller stock. This increased the collection from its previous high of 1,600 specimens to 2,400, a standard that has since been maintained.

Mr. Chrysler permitted the Smithsonian to keep funds that had not been expended on the expedition, and with these were purchased N'Gi, our first gorilla, and saddle-billed and shoebill storks—all spectacular. Despite the fact that it was a very cold day, 40,000 visitors were on hand to see N'Gi when he was placed on exhibition.

Following the Chrysler Expedition, the National Geographic Society financed another one to the Netherlands East Indies (and, incidentally, around the world), resulting in a large assortment of rare small things, a quartette of Nubian giraffes, a pair of gaur from India, and quantities of East Indian birds and reptiles, including 18 birds of Paradise, many rare lories, and a young Komodo dragon lizard about 6 feet long.

In 1940 the Firestone Rubber Company, through Harvey Firestone, Jr., invited the Zoo to send an expedition to Liberia, West Africa, to collect animals, using the rubber plantation as headquarters. Pigmy hippos, several species of small duiker antelopes, monkeys, and rare birds and reptiles were obtained for the Zoo by this expedition.

In 1926 the Congressional Committee on Appropriations had decided that the Zoo did need a new bird house. Money was appropriated, and the building constructed as far as the funds permitted. This was followed by appropriations for a reptile house. Through Smithsonian financing, the Director was able to take Mr. Alfred Harris, the Municipal Architect, to Europe, where all of the worthwhile reptile exhibitions were visited and studies made of the buildings. While the house was being constructed, a short expedition was made to Central America to collect reptiles for the exhibition. The building was opened at a reception in February and stocked with the specimens that had been kept here and there about the Zoo.

The reptile house proved so popular that one evening a Congressman, a friendly member of the Zoo Appropriations Committee, came to the Director and said:

> We realize that the building program for the Zoo that you have suggested so many times is a good one. But on both of the houses that you have constructed, mistakes were made in estimating their cost. We have decided this year to give you money for plans and specifications for the next building, so that you may make a better estimate of the cost. Then when that is being built, another fund for plans and specifications for the following one.

It sounded good, and the building program seemed practically assured. But there was an election, and the chairman of the committee soon returned to his law practice in Nebraska and the friendly Congressman to his farm in Illinois, leaving the Zoo in the midst of the depression with an entirely new and strange committee. There were no more appropriations for buildings, but through some of the relief agencies considerable work was done: ponds for waterfowl were constructed and other improvements that could be made without expensive materials.

The committee had appropriated the

Photo by E. P. Walker

EMPEROR PENGUINS, JACKASS PENGUINS, AND KELP GULLS

ALL THESE BIRDS WERE RECEIVED FROM THE ANTARCTIC AND ARE KEPT IN REFRIGERATED QUARTERS.

sum of $2,000 a year for collecting trips. One was made to British Guiana and one to the Argentine, each resulting in many interesting additions to the collection. A trip to India resulted in the addition of the rhinoceros collected by the Forestry Department of Assam.

In 1935 the Zoo had a great stroke of good luck: The Public Works Administration allotted $680,000 and followed this the next year with $191,000, with which were constructed machine shops, a central heating plant and working facilities, a small mammal house, and a pachyderm house; the bird house was completed, thus giving the Zoo four of the best buildings in the world but leaving three of the most unsatisfactory.

During World War II the Zoo was maintained at almost its normal level; the 48-hour week, put into effect by the government, made up for the decrease in personnel, so the collection was never neglected. Substitutes were necessarily used for numerous ordinary supplies. When flour was scarce, there were utilized great quantities of macaroni products that had been condemned by the United States Marshal and given to the Zoo; a few dried bananas were secured from time to time; Mexican dried insects replaced the ant eggs that had hitherto come from Germany and Japan.

The Army and Navy, especially the Army Medical Corps, sent numerous shipments of specimens, some of them

ex-mascots primarily for exhibition, and others for research; for example, venomous habu snakes were sent from Okinawa so that studies could be made of the venom and the right serum for treatment developed.

IN THE first half-century of its history, the Zoological Park exhibited many creatures that probably will never be seen again in captivity: the West Indian seal, now practically extinct; Tasmanian wolves with young; kiwis from New Zealand; and California condors, one of which has lived 45 years in the Park. At the present time the Zoo contains a representative collection of mammals, birds, and reptiles of the world, with small exhibits of fish and insects. Its popularity is attested by the attendance, which numbers well over 2,000,000 each year. Thousands of school children in organized classes, artists, photographers, and students of natural history show that the Park is functioning in the purposes for which it was established.

WILLIAM MANN

WILLIAM MANN, Sc.D., has been Director of the National Zoological Park since 1925. He was born in Helena, Mont., July 1, 1886. It would be interesting to know how many miles he has traveled during the past sixty years. He studied from one side of the country to the other: Staunton (Va.) Military Academy, State College of Washington, Stanford University (B.A., 1911), and Harvard University. At Harvard he was a graduate student at the Bussey Institution, specializing on ants under William Morton Wheeler. Like Wheeler, Dr. Mann spent as much time as possible studying zoology and entomology in the field. During all vacations he collected natural-history specimens, making trips to Mexico, Cuba, Haiti, western Asia, and South America. Taking his Sc.D., in 1915, he collected in Fiji, Australia, and the Solomon Islands as a Sheldon Traveling Fellow of Harvard. From 1916 until he became Director of the Zoo he was in the Bureau of Entomology of the U. S. Department of Agriculture. Even there he managed to travel, investigating insect pests in the American tropics and in Europe. And in 1922 he accompanied the Mulford Biological Exploration of the Amazon Basin across South America. He must have been unconsciously preparing himself for the position he has held with distinction for the past twenty years. Nearly everyone knows that Dr. Mann is Director of the Zoo, and those who are acquainted with him may have the privilege of seeing the Zoo "under the best auspices"; that is, by touring the Zoo with Dr. Mann himself. Always full of enthusiasm, he is the most entertaining guide to be found in Washington. Now and then he has left the Zoo to direct expeditions for the purpose of collecting and bringing back live animals. He headed the Smithsonian-Chrysler Expedition to East Africa, the National Geographic Expedition to the East Indies, and the Smithsonian-Firestone Expedition to Liberia. And he has made shorter trips to Central and South America.

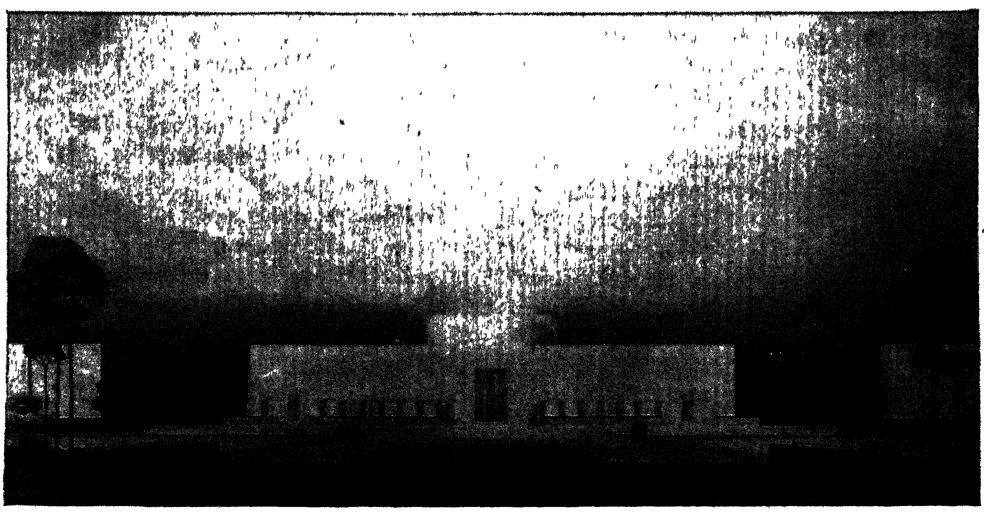
A NATIONAL MUSEUM OF SCIENCE, ENGINEERING AND INDUSTRY

By FRANK A. TAYLOR
CURATOR, DIVISION OF ENGINEERING, U. S. NATIONAL MUSEUM

ONE day the United States will have a national museum of science, engineering, and industry, as most large nations have. Normally, it will be a part of the National Museum under the direction of the Smithsonian Institution and will be based in part upon the present extensive collections of the Smithsonian in these fields. Like all museums of the Smithsonian, this one will be a museum of record as well as of exhibition. As part of the National Museum, its scope will include all the sciences except the natural sciences and all of engineering and industry, including agriculture. In size it will be modest but adequate for many years.

The museum will carry on and extend the activities of the engineering and industrial sections of the National Museum. These began more than 65 years ago as adjuncts of anthropology with the purpose of showing the machines and industrial processes which derive from primitive tools and methods. A few were started to illustrate applications of the natural sciences, such as mining, which came out of geology by way of economic geology.

The early curators had their choice of material from several great expositions and opportunities for personal contacts with the inventors and industry builders of a half-century ago. They also had the advantages of the Smithsonian's close association with the engineering and industrial branches of the Government, including the Geological and the Coast and Geodetic Surveys, the Fish Commission, the Corps of Engineers, the Lighthouse Bureau, and the Patent Office. Several fine collections were started with early



A NATIONAL MUSEUM OF SCIENCE, ENGINEERING AND INDUSTRY
ARCHITECT'S DRAWING OF A SUITABLE BUILDING THAT MIGHT BE LOCATED AT EIGHTH STREET AND INDEPENDENCE AVENUE, WASHINGTON, D. C. DRAWN BY ROBERT JORDAN HARPER, 1932.

scientific instruments, patent models, and machines from these sources. During the 65 years of the activity many new industries came into being and had their golden years of invention and expansion. Within the limits of space and funds, most of these opportunities to select and collect relics of the beginnings and subsequent developments of scientific and industrial progress were made good.

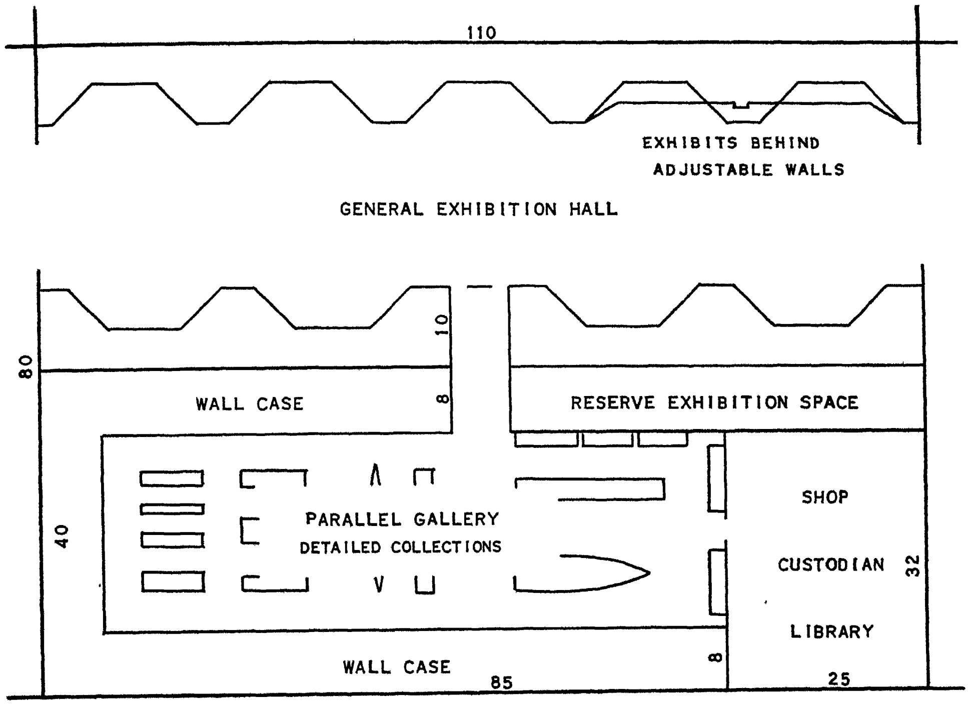
The collections today crowd exhibition and storage space in three buildings of the Smithsonian group and cover (though unevenly) almost the entire scope of engineering, the physical sciences, agriculture, and industry. Engineers, writers, teachers, historians, and inventors make use of the stored and exhibited reference collections, and in spite of a total lack of space in which to set up many worth-while exhibits, a million and a quarter visitors view the collections annually. None of these is adequately served by the present facilities of the museum.

The new museum will continue as a museum of record, to gather the instruments, machines, and papers which mark progress in science, engineering, and industry and preserve them in collections and exhibits for study. In addition it will be a museum of real exhibits which will memorialize the pioneers and venturers and offer instruction in history as well as current information in its fields. The student will continue to find the source materials and the facilities for his studies in the *collections;* the casual or curious visitor will be impressed, entertained, and instructed by the fine *exhibits.*

The plan of museum which seems to offer the most to each class of prospective user of a museum of this type is one form of the parallel gallery plan. It divides the public halls of a museum into an easily traveled route of exhibition spaces for the visitor who comes to look and a system of adjacent parallel halls which are open to all but require some conscious effort on the part of the visitor to enter. The parallel halls are for the detailed material worthy of exhibition but of less than general interest to the crowds of museum visitors. In adopting this plan we discard the step-by-step chronological development of subjects in the general exhibition halls and make no attempt to confine the visitor to a particular route, except to make the way through the exhibition spaces the easiest and most attractive to follow.

Consider as an example the Marine Section—a subject to which entire museums are devoted. We tentatively reserve *nine* exhibition spaces for it. At any particular time these might be devoted to three (more or less) subjects of current information and a half-dozen of historical and technical interest. Current-interest subjects might include exhibits on "The Need for an International Agreement on the Eight-Hour-Day at Sea," "Our Place in the Postwar Maritime Trade," or "The Lakes Ore Carriers." Other exhibits might be "The Annual Manila Galleon," "Small Sailing Craft of New England," "What Was a Clipper Ship?" "The Coal Trade and Coal Schooners," and "The Northwest Passage." Each would tell a complete story presented with a minimum of distracting detail. One might remain on exhibition indefinitely; another might be on for days only.

Exhibits in other sections will be similarly selected, and our museum for the casual visitor will be a succession of such groups. He will find that the easy way to go will be through these exhibits, but nothing will prevent his short-circuiting the tour or digressing into a parallel gallery. The entire purpose is to present to him efficiently a succession of items of more or less general interest, to make it easy for him to select the exhibits he wishes to examine, and, above all, to repay him richly for any attention that he



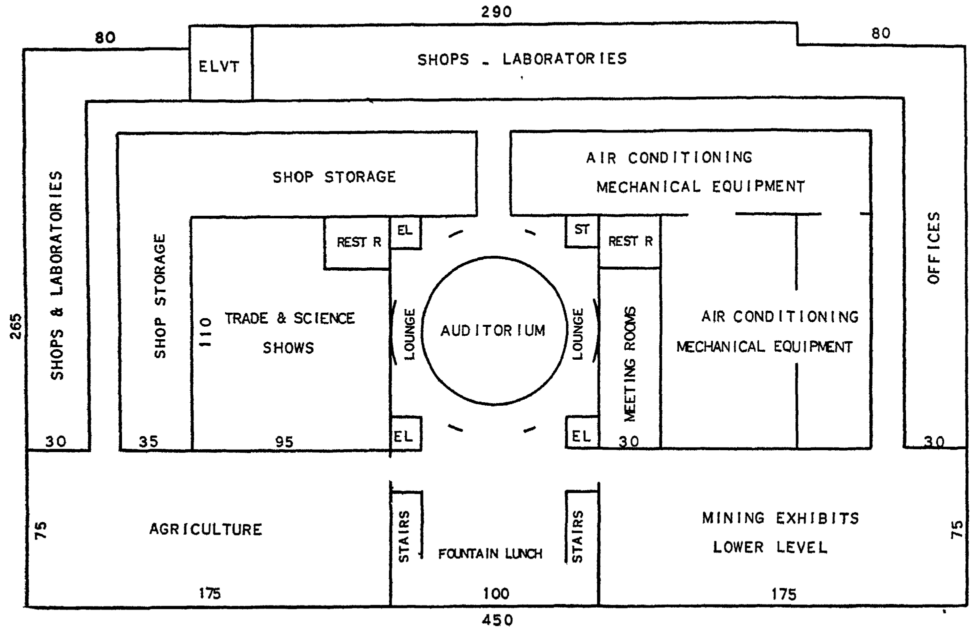
THE PROPOSED NATIONAL MUSEUM OF SCIENCE, ENGINEERING AND INDUSTRY
GALLERY PLAN FOR THE MARINE SECTION IN WHICH THE EXHIBITION HALL HAS 30-FOOT CEILING AND THE PARALLEL GALLERY A 15-FOOT CEILING WITH A DECK OVER IT. ATTIC OVER ALL.

gives to a display. In these spaces, the economic, social, and cultural effects of technical and scientific advances will be described from time to time.

The way through the exhibits will be laid out so that the visitor will be little aware of the existence of the parallel galleries. However, if he should become interested in what is in one, he will have to make a turn from the obvious way and pass a large room label which will inform him of what is ahead and urge him to go back to the main track of general exhibits unless he has an interest in the details of the subject ahead. If he goes into the gallery with this warning, he is assumed to have an interest beyond that of the casual visitor and will recognize the material there for what it is without the benefit of emphatic display.

The visitor will find the bulk of the collections in these parallel galleries. Material will be exhibited in them somewhat as it is in the halls of the National Museum today, that is, practically stored behind glass. However, it will be patently stored in the new museum, and the fixtures will be designed both to exhibit their contents and to permit handling of the material under the supervision of an attendant.

To continue the example of the Marine Section, its parallel gallery will contain most of the material that is in the boat hall today. This consists of the scores of contemporary rigged models of sailing and steam vessels, the original builders' models of American vessels beginning in the early 1800's, the display models representing types of vessels important in the development of our maritime affairs and those that represent the work of the pioneer inventors in both sail and steam. Such items as navigating instruments,



BASEMENT PLAN—CEILING HEIGHT, 20 FEET

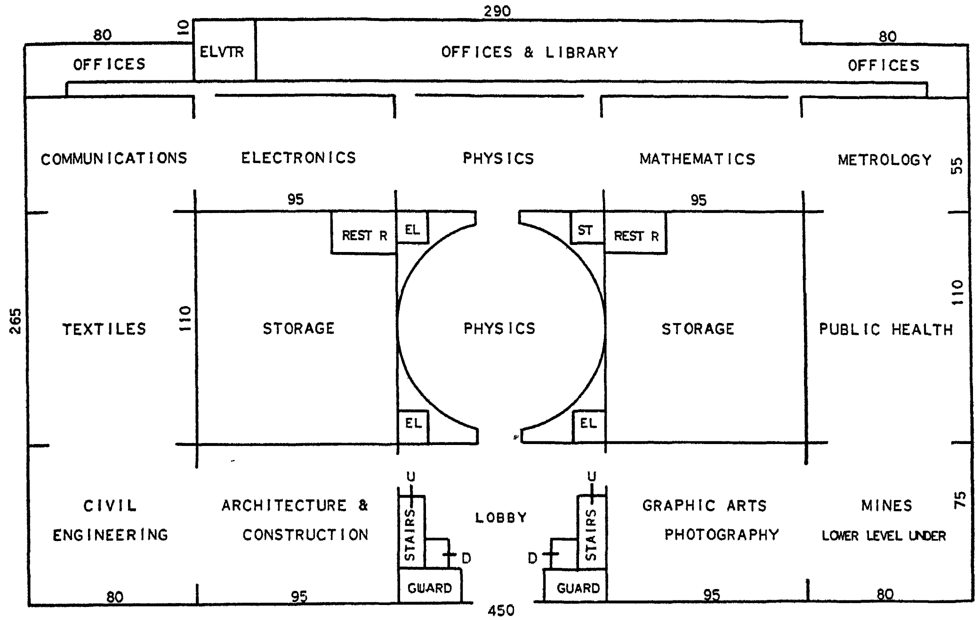
shipbuilding and rigging tools, and full-size and model primitive craft will be included. This material will be exhibited as well as it is now, and some, such as the builders' half-models, would be brought down from the walls to a better viewing position. All will be lighted and readily accessible for removal from cases for closer inspection. The material will be crowded to conserve space, but it will be labeled, organized, and exhibited sufficiently well for the examination of individual items. Comparable material in other sections will be similarly exhibited.

Having such detailed material displayed rather than shut up in office collections serves several purposes. The student can see quickly the breadth and depth of the collection as it relates to his study, a visitor with a special interest can search out many of the details of his subject without help from the staff, and public recognition is given to the accomplishments of the many American scientists, engineers, and industrialists whose work is exhibited in the parallel galleries. If only for the many who come to the museum to poke about, the display of detailed material in the parallel galleries is worth while. Also, this type of display is closely identified with the "Old Smithsonian" museum, and many would regret its elimination.

A THIRD important element of the museum consists of stored study collections or office collections. These contain the very detailed and extensive groups of machines, instruments, patent models, accessories, parts, chemical types and raw materials, drawings, documents, and the sections' libraries and photographic files —to mention only a part. These collections will be under the supervision of the curators and their assistants, who will oversee their use.

The office collections and the material in the cases in the parallel galleries constitute the consultative and record collections of the museum. They will be readily accessible at all times for study.

To sum up the treatment of the collec-



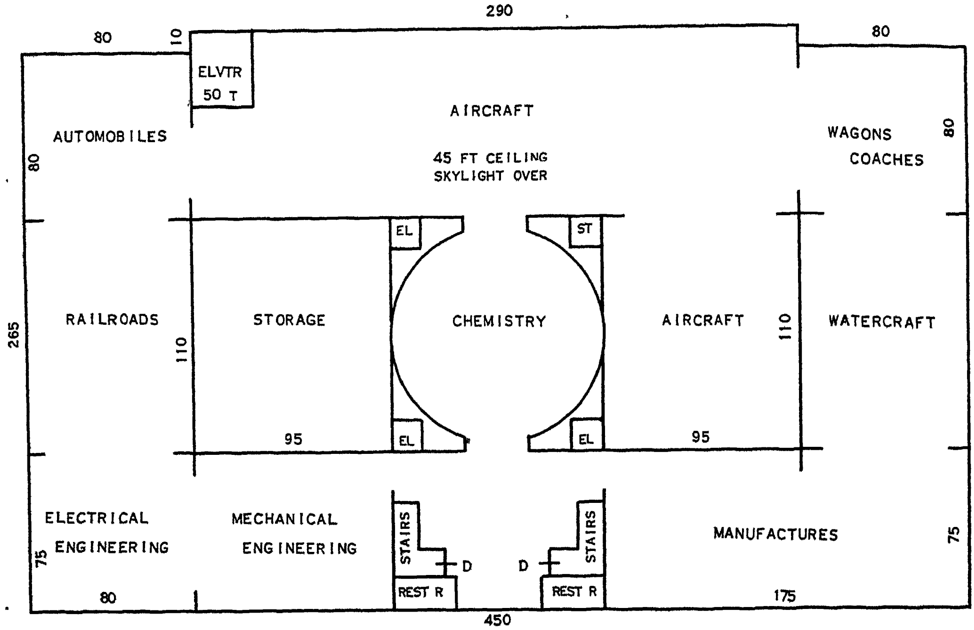
FIRST FLOOR PLAN—CEILING HEIGHT, 20 FEET

tions: The exhibits will be uncrowded spot displays, easily changed and flexible in size, arrangement, and relationship to one another; the parallel halls will contain the material appealing to those with special interests, and the office collections will contain the material not suitable for even limited display, though it may often be the material of most historical or technical interest.

Reference to the plan of the Marine Section will show the development of this plan in one rectangular hall of the proposed building. Exhibition space is located along the interior walls, and the exterior side, with possibilities for windows, is used for the parallel gallery where considerable time will be spent by staff members and students. The room at the end of this particular parallel gallery is a small workshop and library occupied by a staff attendant, who will assist inquirers in the use of the collections. He will remove objects from cases for examination, oversee the use of the office collection material, and, when not otherwise employed, repair and maintain the collections. The workshop space will have one gallery for bookshelves, which will connect with a storage deck over the reference exhibit hall and also with the attic space over all.

In the space reserved for the general exhibits, the fronts of the individual exhibition spaces form the side walls of the exhibition hall. They will be constructed of panels on a number of module dimensions which can be combined to vary the walls to form shallow and deep alcoves. These panels in turn will be made with a variety of apertures which will look into enclosures of different depths up to rooms 10 feet by 12 feet. Obviously, space will be wasted when flush or shallow enclosures are used, but this is justified by the economy of effort in changing displays. This plan is generally adaptable to all subjects and sections.

This leaves size to be considered, and determining the size of a museum is an essentially arbitrary procedure. There is no limit to the possible development of



SECOND FLOOR PLAN

CEILING HEIGHT, 30 FEET, WITH ATTIC OVER ALL EXCEPT FOR SKYLIGHT OVER THE AIRCRAFT EXHIBIT.

a museum with the broad scope of this one. Almost any section could be expanded into a substantial museum with valid justification. For example, the Congress received and passed a bill to authorize the National Air Museum as a bureau of the Smithsonian Institution while this article was being written. Some staggering ideas as to the size and scope of that museum have been ventured. One calls for a vast collection containing examples of every type of airplane, engine, instrument, part, and accessory that can be procured, requiring 2½ to 3 million square feet of space. Assuming such a collection is made, there is the question of its practical relationship to a public museum. Only a tiny fraction of it could be seen by the thousands of people who would be attracted to it. The collection might be housed and operated more efficiently as a research "library" of machines, separate from the functions of public display and commemoration. If so, the space set aside in our plan might still be sufficient for the public activities of the National Air Museum. Anyway, we have left it in as a fine example of the spread of ideas about size.

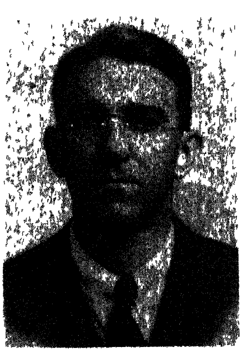
The building we propose is a rectangular one 450 feet long by 275 feet deep to fit the area between Independence and Maryland Avenues and Seventh and Ninth Streets facing the Mall in Washington. This lies between two triangular areas which are looked upon as the space into which to expand the museum when necessary. The building is a three-storied one, entered on the first, or ground, floor with a basement below and the main floor above. All three floors will be used for exhibition spaces and parallel galleries. An "attic" extends over much of the top floor. The building is as plain as is appropriate for its neighborhood. The halls are few in number but large in size and rectangular or square in shape. The maximum use of false walls and decks will be made to

adapt a room to its contents. A plentiful supply of underfloor service channels and movable exhibition space fronts is expected to make it easy to fit the rooms to the collections. Each room will be divided into exhibition space and parallel galleries as required.

In considering size it will be seen that the Marine Section is housed in a space 80 feet by 110 feet, part of it two stories high with an attic over all. The parallel gallery alone is as large as the exhibition space now devoted to these collections, and the storage space is a complete gain. It is believed that this amount of space would continue to accommodate this section for an indefinite period of time much more efficiently than it is housed now. Similarly, the space allotted to other sections is two to three times greater than now occupied.

It is expected that a tour of the exhibition spaces in all halls would require about two hours at a pretty fast rate of inspection. This, unfortunately, is more than twice as much time as the average visitor allows himself or is allowed by his sightseeing tour or guide. If this condition continues—and it probably will—this amount of general exhibition space will be adequate indefinitely. Given a considerable number of striking displays, there can be little objection to some crowding of the bulk of the exhibited collections in the parallel halls. This means a great economy of space as compared with the present showing of material combining both exhibition and public storage. As little proper storage space is now available to these sections, the large volume of storage space in the plan makes it infinitely adequate from that point of view. Barring changes in scope and policies, the proposed museum can be expected to serve all the functions of the museum of its type indefinitely.

FRANK A. TAYLOR



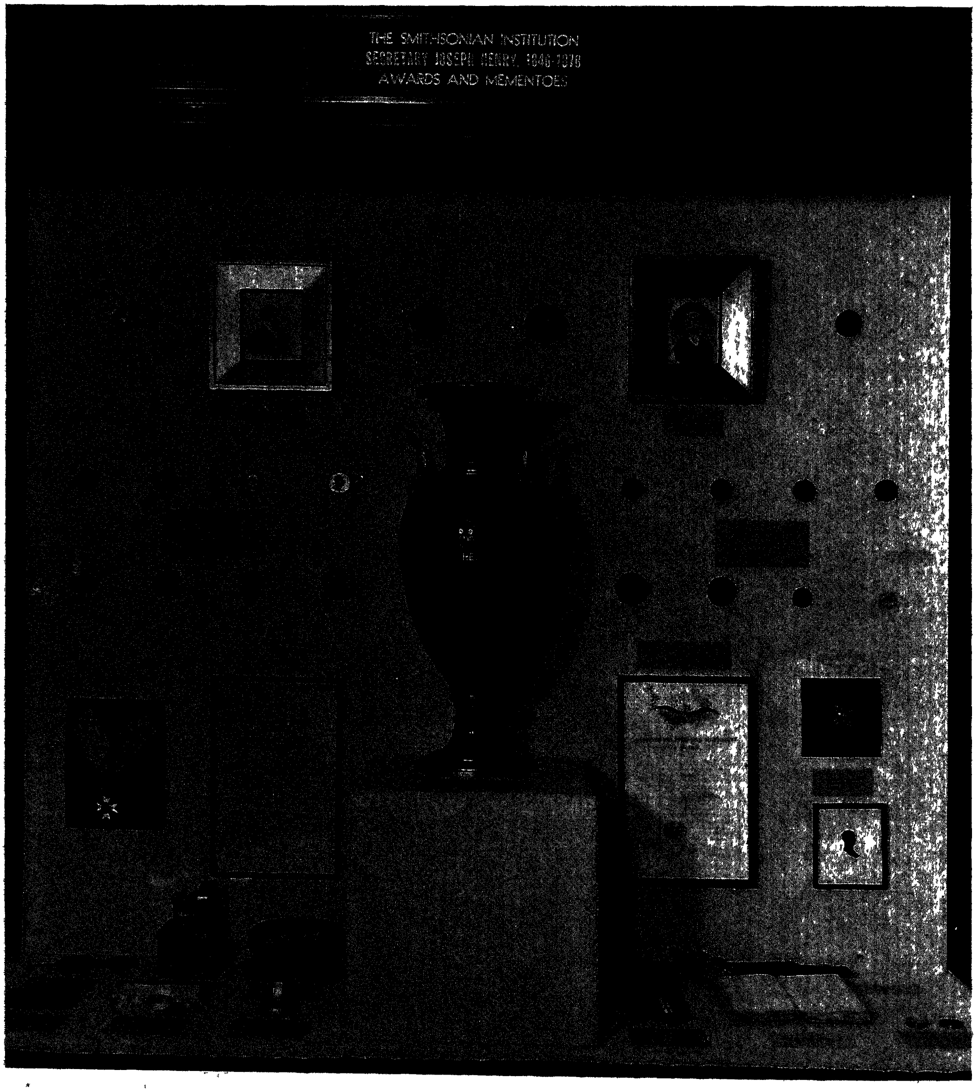
Frank A. Taylor, B.S., LL.B., is a moderately old hand at the museum business. In a quarter-century (less a few months) with the National Museum he has worked through the museum routine of modelmaking, preparation of exhibits, collecting and preservation, research and writing—all in the field of the history of engineering and related museum activities. An occasional time out was taken to acquire a B.S. in mechanical engineering (M.I.T.), for a considerably less than "grand tour" of the European technical museums (1926), a short turn at teaching (Catholic University), for a law degree (Georgetown), to act as associate director of Federal Works Project No. 6, "The Historic American Merchant Marine Survey," (W.P.A.), and to command an antiaircraft gun unit in the south and west Pacific (A.U.S.). Mr. Taylor is a member of the American Society of Mechanical Engineers and of the Ship Model Society of Washington, D. C.

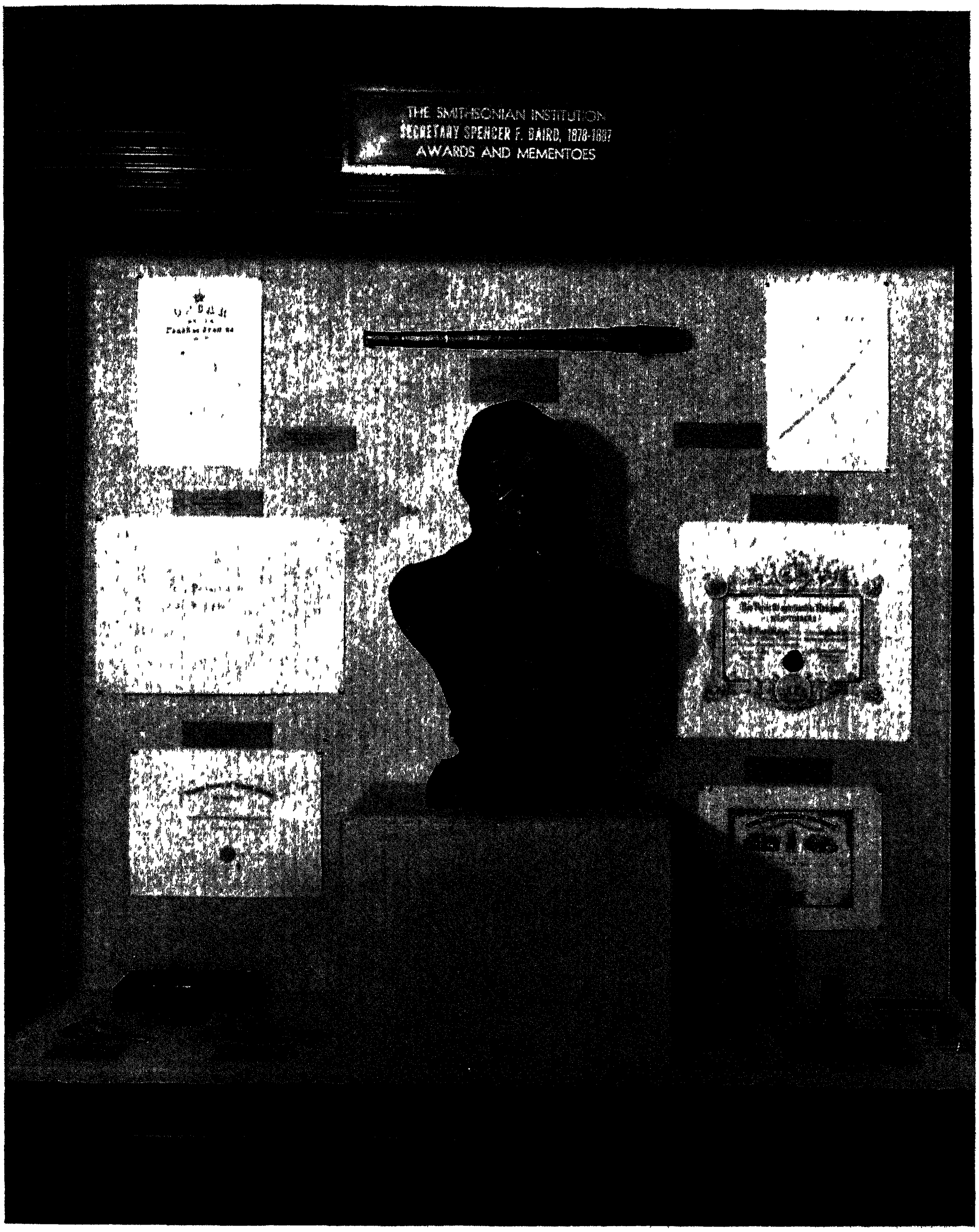
THE SECRETARIAL CASES*

By THEODORE T. BELOTE
CURATOR, DIVISION OF HISTORY, U. S. NATIONAL MUSEUM

As A part of the present temporary exhibition of museum materials in connection with the commemoration of the centennial anniversary of the founding of the Smithsonian Institution, a series of four large cases containing objects of personal and scientific interest in the careers of the first four secretaries of the Smithsonian Institution has been installed in the main hall of the original Smithsonian Building. The contents of these cases illustrate in chronological order the work of the distinguished scien-

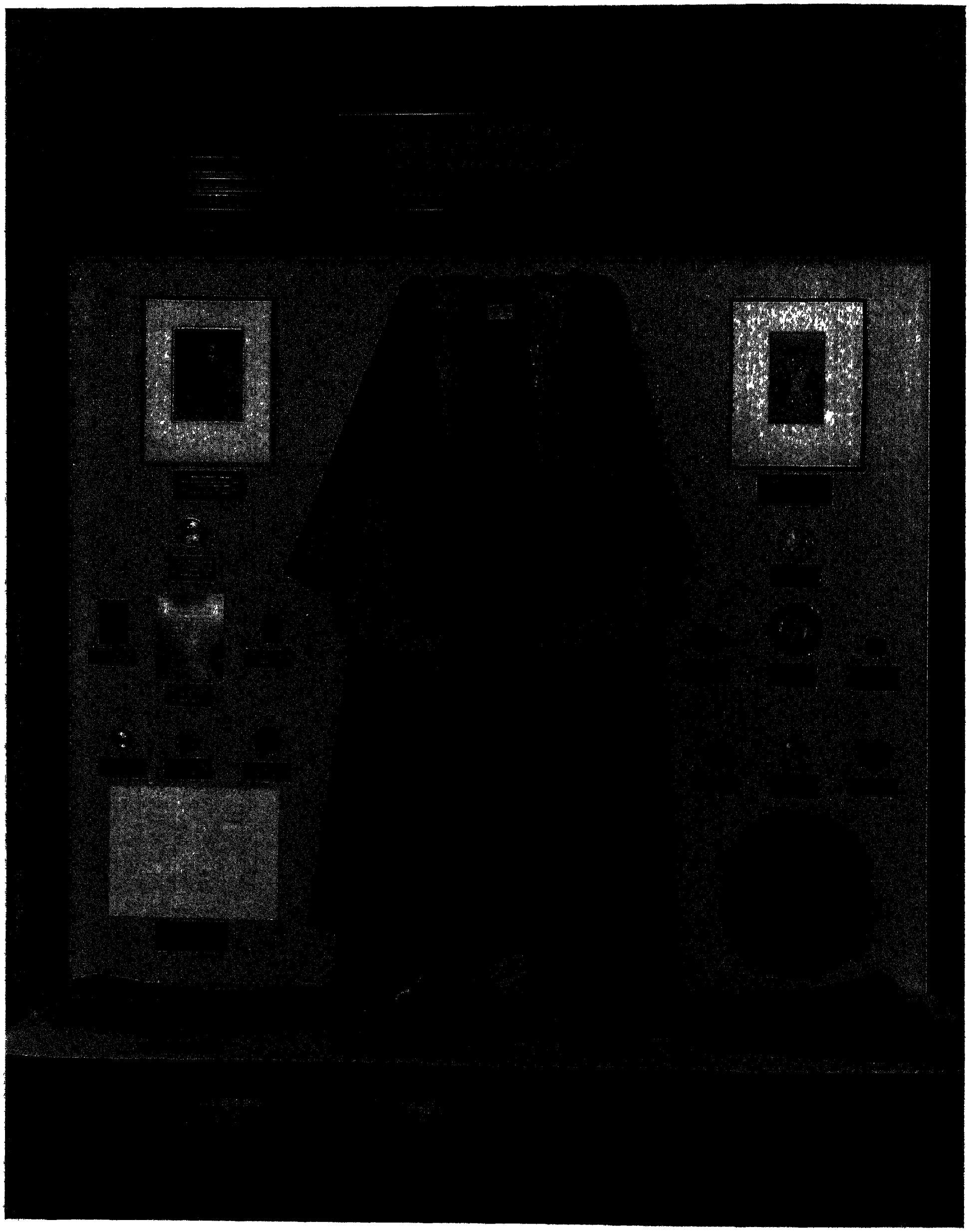
* Owing to lack of space, photographs of only one of the two sides of these exhibition cases are here published.—Ed.





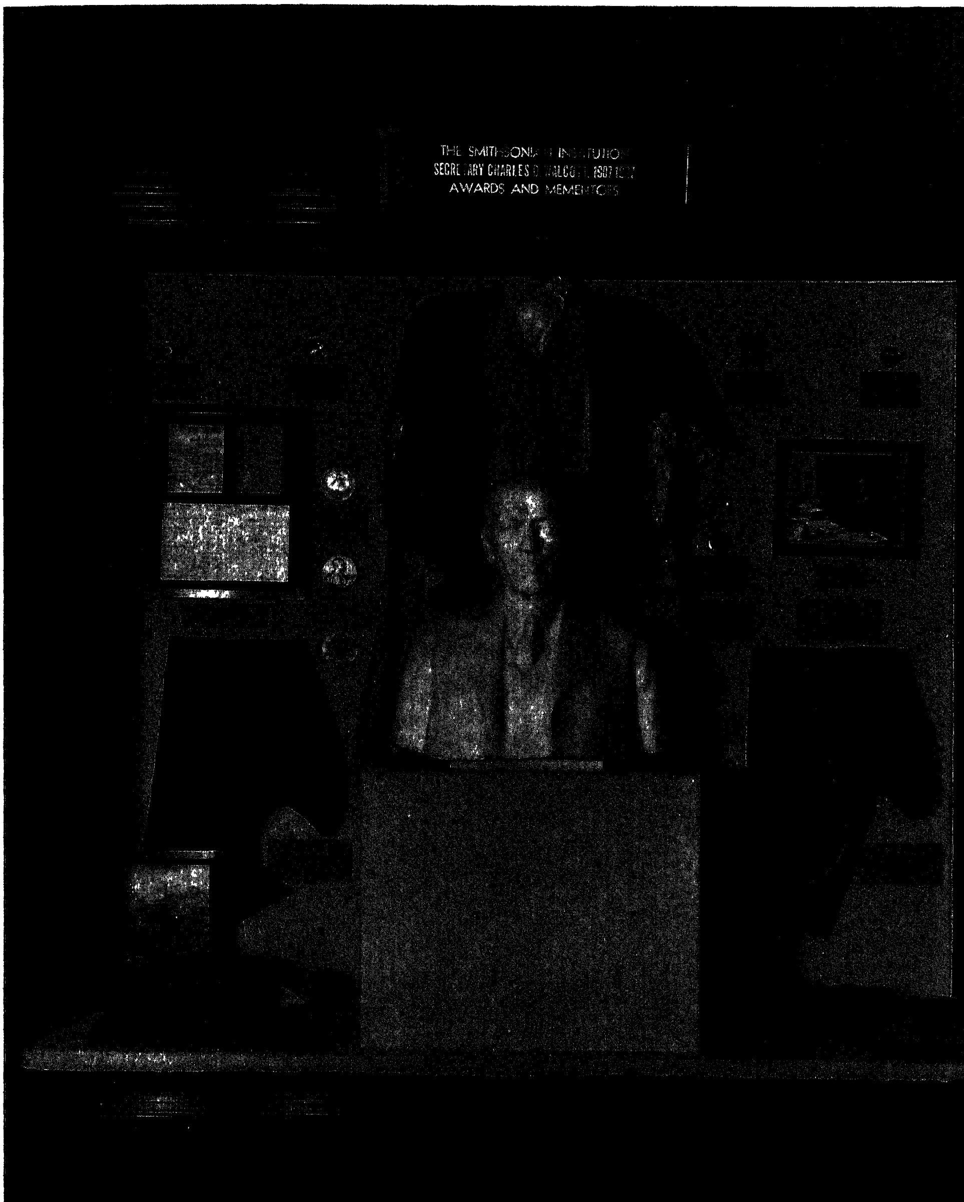
tists who served as secretaries of the Smithsonian Institution from 1846 to 1927: Joseph Henry, 1846–1878; Spencer F. Baird, 1878–1887; Samuel P. Langley, 1887–1906; and Charles D. Walcott, 1907–1927.

The case representing the career of Joseph Henry, Secretary of the Smithsonian, 1846–1878, contains a model of the electric magnet made by him for the Yale College laboratory in 1831 and various small pieces of apparatus used by him in his physical experiments. The objects of personal interest shown in the



case include water-color portraits of Joseph Henry and his mother; the first scientific book used by him; the order of Saint Olaf awarded him in 1870 by the King of Sweden and Norway; gold, silver, and bronze medals presented to him; diplomas and certificates of membership in various scientific societies; and various other mementos of his career.

The case representing the career of Spencer F. Baird, Secretary of the Smithsonian, 1878–1887, contains specimens of birds collected by him when a youth, a field glass and some of the scien-



tific instruments used by him in his work as a naturalist. The objects of personal interest in this case include a plaster bust of Secretary Baird, a letter written by him, one silver and two gold medals, and diplomas and certificates of membership in various scientific societies awarded him in recognition of his scientific achievements.

The case representing the career of Samuel P. Langley, Secretary of the Smithsonian, 1887–1906, contains various pieces of apparatus used by Secretary Langley in his experiments in

physics and aeronautics. These include a bolometer, a telephoto camera, and a revolving sector photometer. The objects of personal interest in this case include two water-color portraits of Secretary Langley, a number of gold medals, and pieces of academic costume worn by him when he received honorary degrees from American and foreign universities. With these objects are shown four of his scientific publications.

The case representing the career of Charles D. Walcott, Secretary of the Smithsonian, 1907–1927, contains examples of the trilobites collected by him in his work as a geologist, his appointment as Director of the Geological Survey in 1894, and the letter written by him to Chief Justice Melville W. Fuller accepting the appointment as Secretary of the Smithsonian. With these objects are shown several gold medals awarded to Dr. Walcott in recognition of his work as a geologist, diplomas representing honorary degrees from American and foreign universities, and various pieces of academic costume worn by him at the time of his acceptance of these degrees. In this case are also shown a marble bust of Secretary Walcott and a gold watch and chain worn by him for a long period.

The four cases just described contain a collection of materials which illustrate in a striking manner the personalities and the individual achievements of the four secretaries of the Smithsonian Institution represented by these exhibits. They also represent some of the important phases of the scientific work of the Smithsonian during the period of their administration, 1846–1927. The present location of the cases in the original Smithsonian Building is ideal from the viewpoint of historical significance.

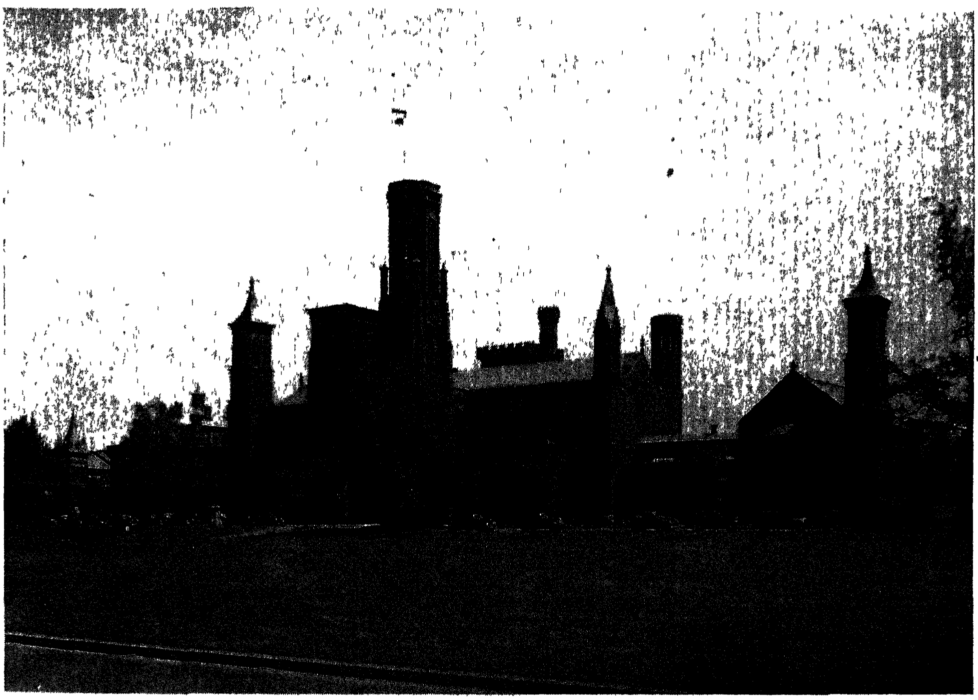
THEODORE T. BELOTE

Theodore T. Belote, A.M., has been Curator of History, U. S. National Museum, since 1908. His Division of History "administers not only the great collections of civil, military, and naval historical material, but also coins, medals, and stamps." Mr. Belote was born in Bridgetown, Va., on May 3, 1881. He graduated from Richmond College (Va.) in 1902 and for the next six years pursued graduate work in history at the following institutions: Richmond College, University of Berlin, Harvard University, University of Cincinnati, and the University of Leipzig. At the end of his second year in Germany he was appointed to his present position. At the University of Cincinnati (1906–07) he was Colonial Dames Fellow in Ohio Valley History. He is the author of "The Scioto Speculation and the French Settlement at Gallipolis," 1907; "American and European Swords in the Historical Collections of the United States National Museum," and various essays on historical museum subjects.

THE DIVISION OF RADIATION AND ORGANISMS: ITS ORIGIN AND SCOPE

By EARL S. JOHNSTON
ASSISTANT DIRECTOR, DIVISION OF RADIATION AND ORGANISMS, ASTROPHYSICAL OBSERVATORY

In 1895 Dr. Charles Greeley Abbot was appointed as an aid in the Astrophysical Observatory. This branch of the Smithsonian Institution had been established by Secretary Samuel Pierpont Langley for the purpose of investigating the energy of the sun and the distribution of its radiation in the spectrum. Upon the death of Secretary Langley in 1906, Dr. Abbot was made Director of the Observatory, and his interests grew from the mere measurements of solar radiation to the effects this radiation has on the flora and fauna of the earth, on the weather, and on mankind in general. During a voyage to Australia in 1914, he discussed extensively with Dr Lyman J. Briggs, who later became Director of the National Bureau of Standards, the subject of photosynthesis, the basic reaction in green plants upon which all life depends. It is not surprising that shortly after he became Secretary of the Smithsonian Institution on January 10, 1928, he set about to put into reality some of his earlier dreams of important lines of research.



GENERAL VIEW OF THE SMITHSONIAN BUILDING
THE OFFICES OF THE DIVISION OF RADIATION AND ORGANISMS ARE LOCATED IN THE FLAG TOWER AND ITS LABORATORIES ARE IN THE BASEMENT OF THE WEST WING (ON THE RIGHT).

In a letter dated February 11, 1928, to Colonel Isaac N. Lewis, Dr. Abbot wrote:

In order that, as you requested, some minute of our conversation of February 9 should be preserved, I am sending you a short summary of the work in radiation which I am hoping to undertake.

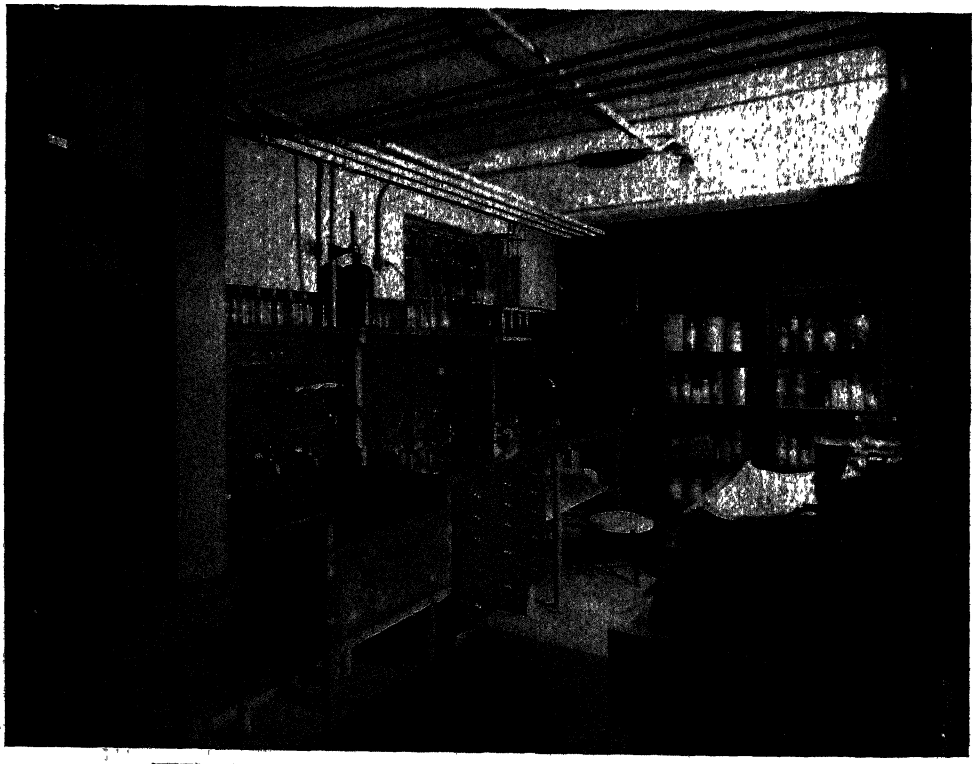
Of course, as Uncle Joe Cannon said, "Everything hangs upon the sun"—the weather, the growth of plants, the health of man and animals. For many years the Smithsonian Institution has been measuring, at selected cloudless stations, the intensity of the solar rays. . . . This quantity, expressed in appropriate units, is called the "solar constant of radiation." . . . From these studies of the intensity of the sun's radiation which have gone on now a good many years, there are three important branches which, as yet, we have scarcely explored at all. They are: First, the relation of solar radiation to the growth of plants; second, the effects of solar radiation on the health and growth of animals and human beings; and third, the dependence of world weather on solar radiation.

Dr. Abbot had particularly wished for many years to undertake the first above-mentioned branch, namely, the relation of solar radiation to the growth of plants. The Astrophysical Observatory had acquired much experience in the measurement of radiation and of heat and had a collection of large pieces of optical apparatus which, when combined, comprised a unique preparation for research on the relation of radiation to life. He was successful in obtaining financial support from the Research Corporation and announced in the annual report of the Smithsonian Institution:

It is therefore with unusual satisfaction that I record the establishment on May 1, 1929, of the Division of Radiation and Organisms.

The purpose of this division is to undertake those investigations of, or directly related to, living organisms wherein radiation enters as an important factor.

In this manner the Smithsonian Insti-



VIEW OF A SECTION OF THE CHEMICAL LABORATORY

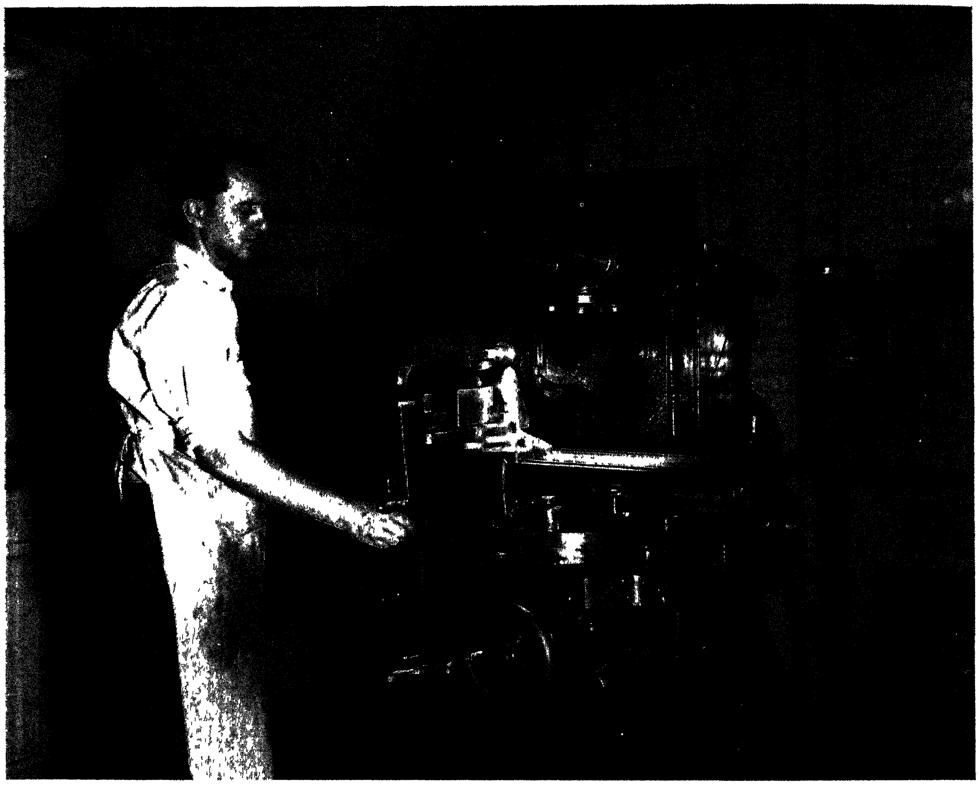
GLASSBLOWER'S BENCH
SPECIAL GLASS APPARATUS AND SENSITIVE LIGHT MEASURING INSTRUMENTS ARE CONSTRUCTED HERE.

tution's youngest unit, the Division of Radiation and Organisms, came into being. An elevator was installed and offices built and furnished in the North, or Flag, Tower of the Smithsonian Building. The basement of the west wing, used previously for storage, was renovated and equipped for laboratory purposes. This laboratory space was ideally suited for the purposes desired. The thick walls of its partly underground rooms insured an evenness of temperature; daylight could easily be excluded in rooms where artificial illumination was to be employed. The original personnel staff under Dr. Abbot's direction consisted of: F. S. Brackett, Research Associate in Charge; Earl S. Johnston, Consulting Plant Physiologist; L. B. Clark, Research Assistant; and Virginia P. Stanley, Stenographer and Laboratory Assistant. During the early development of the Division close cooperation was maintained with the Fixed Nitrogen Laboratory and other bureaus of the Department of Agriculture and with the University of Maryland. It greatly benefited by the advice and cooperation of Dr. F. G. Cottrell and Dr. W. T. Swingle.

The original program of investigations fell into two main divisions:

I. Direct investigation upon living organisms.
II. Fundamental investigations related to biological problems.
  1. Molecular structure investigations.
  2. Photochemical investigations.

From the beginning most of the research has concerned itself with direct investigation upon living organisms, and with few exceptions this work has been carried out on physical problems having a direct bearing on biological investiga-



A PORTION OF THE MACHINE SHOP

tions. A large proportion of this work has depended upon the ingenious designing and construction of original apparatus in the Division's shops.

Extremely close relationship had always existed between the Astrophysical Observatory and the Division of Radiation and Organisms. Frequently, common use was made of its apparatus, shop equipment, and personnel. With the growth and development of the Division it became financially more and more difficult to support it from the private funds of the Institution, so that as of July 1, 1941, its members were given Civil Service status and its work was then carried on from appropriations allotted to the Astrophysical Observatory. The work of the Astrophysical Observatory is now carried on by its two divisions, Astrophysical Research and Radiation and Organisms.

A large proportion of the research carried on by the Division of Radiation and Organisms has been distinctly fundamental in nature. The counsel of its members has been sought constantly on technical and research problems in the field of radiation and its relationship to living organisms. During the period of World War II its regular work was suspended in order that its staff members could devote their time to some of the immediate needs of the day. This work dealt mainly with problems of deterioration of cloth, cardboard, and electrical wire insulation by molds and by ultraviolet light. Other work was related to emergency rescue equipment dealing with the production of potable water from sea water by chemical methods and solar distillation. The termination of this emergency work permitted the resumption of the Division's regular re-

search program. At present this program is focused on problems dealing directly or indirectly with photosynthesis, respiration, and factors influencing plant growth, with special emphasis on wave-length effects of radiation.

SPACE does not permit more than a mere mention or brief discussion of the Division's work. It should be pointed out at this time that in most of the research involving the measurement of radiation these measurements have been made by means of a vacuum thermocouple of extremely high sensitivity, designed and constructed by Mr. L. B. Clark, a member of the Division since its origin. This couple is made of three-part alloy wires, drawn down to a very small diameter and for some purposes etched to 4 to 5 μ diameter. It is remarkably sturdy. Because of its excellent characteristics, this couple has been in great demand in other laboratories throughout the country.

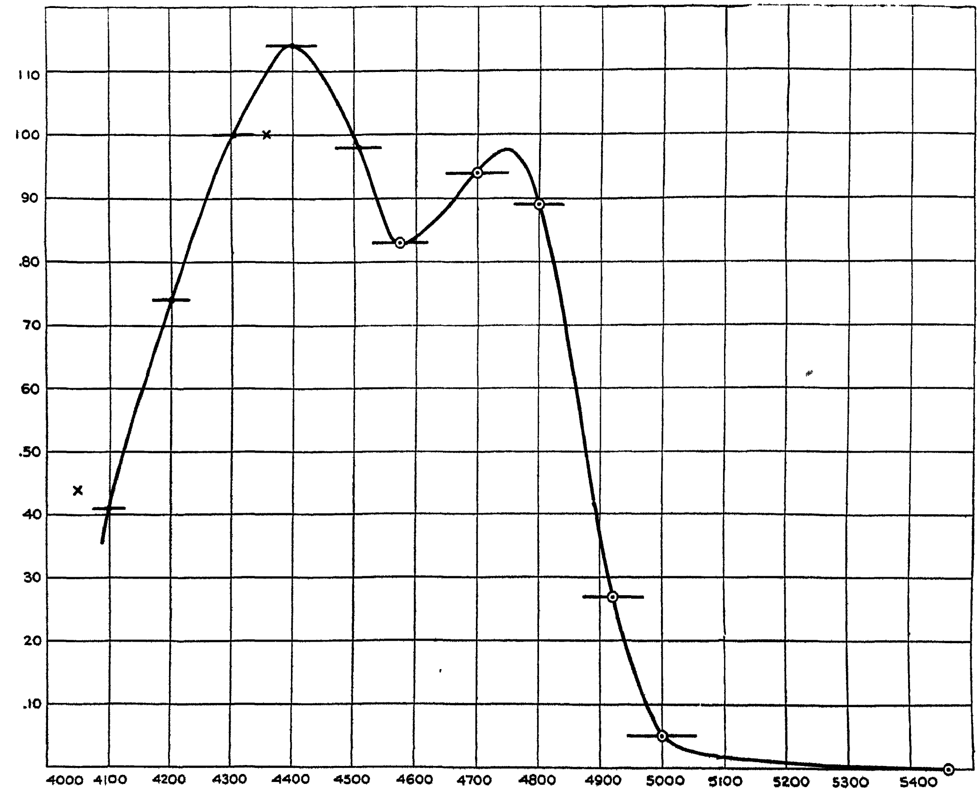
One of the most commonly observed responses of plants to light is phototropism. A potted plant growing in a well-lighted window soon grows toward the light and, unless it is turned frequently, a marked lopsided growth results. Many other examples could be given of plants bending toward light. One of the early problems undertaken by the Division was to study the wave-length effect of light on this specific type of plant growth. Would the bending take place equally well in red light and in blue light? Or is the plant sensitive to one color and not to another?

The general procedure used in studying the wave-length effects in phototropism was to place an oat seedling between two different lights. After a time interval the seedling was examined for a one-sided growth. If, for example, when the seedling was exposed to blue light on one side and to green on the other, a distinct bending was noted toward the blue light, it was then known that the blue light exerted a greater retarding action, since the side of the seedling toward the green light grew more, thus bending the seedling toward the blue light. The lights were then so adjusted as to increase the green or decrease the blue intensity. Another seedling was used and the process repeated until a balance point was obtained where the effect of one light neutralized the effect of the other When this point was determined a specially constructed thermocouple replaced the seedling and by means of a galvanometer the light intensities were measured.

From many such experiments in which seedlings were grown between lights of different colors, a wave-length sensitivity curve, or action spectrum of phototropism, was constructed. In this curve the sensitivity of the oat coleoptile was plotted vertically and the wave length of light plotted horizontally. The sensitivity increases rapidly from 4100A to 4400A, then falls off somewhat to about 4575A, and again rises to a secondary maximum at about 4750A. From this point the sensitivity decreases rapidly to 5000A, from which point it gradually tapers to 5461A, the threshold of sensitivity on the long wave-length side. Briefly, it can be concluded that the region of greatest sensitivity is in the blue; that is, growth is retarded most in blue light. Orange and red light have no effect in retarding this particular type of growth.

A marked effect of temperature upon the growth inhibition of the oat coleoptile by light has been observed. Below 25° C. the inhibition is independent of temperature; between 25° and 30° the inhibition effect becomes smaller as the temperature increases; above 30° there is no inhibition and possibly a slight stimulation by light. These findings apply, of course, only to the specific conditions of intensity and wave length which have been studied.

Light to be effective in this and other



PHOTOTROPIC SENSITIVITY CURVE

THE RELATIVE SENSITIVITY VALUES ARE PLOTTED VERTICALLY AND THE WAVE LENGTHS, IN ANGSTROMS, HORIZONTALLY. THE HORIZONTAL BARS INDICATE THE WAVE-LENGTH RANGES AT THE BALANCE POINTS. CIRCLES INDICATE POINTS OBTAINED WITH FILTERS COMBINED WITH THE MONOCHROMATOR. POINTS MARKED X INDICATE THE USE OF MERCURY LINES.

reactions must be absorbed. This postulates the presence of light-absorbing substances. It is interesting to note that attention has been called to the similarity of the carotene absorption curves to those of the action spectrum of phototropism. Other investigations indicate that phototropism is associated with auxin, or growth substances, found in plants, and considerable work as to the effect of wave lengths on these materials has been continued. Light in some manner inactivates the auxins on the illuminated side or it causes them to migrate to the shaded side or perhaps does both, thus resulting in a greater cell elongation on the shaded side. In addition to the effects of radiation itself other environmental factors such as temperature, mineral nutrition, and aeration have been studied. Additional data have been obtained regarding the action spectrum of mesocotyl inhibition in oats over a wide range of light intensities. At low intensities a maximum occurs at 6600A and a second maximum in the neighborhood of 6200A. Comparisons have been made of the effectiveness of red and of violet light for several other species representing a majority of the tribes of grasses. The response to all species have been found to be fairly similar to that of *Avena.*

A very interesting effect of light upon root growth has been noted. Roots caused by mechanical restraint to grow

in a horizontal direction elongate at their normal rate in darkness, but are greatly inhibited by light. In addition to the interest in the mechanism by which this result might be caused, it is noted that red light is effective, indicating the presence of a pigment which absorbs these wave lengths.

Just as certain wave lengths of light may accelerate certain growth processes and others retard them, there are some that are harmful and even lethal. In a series of experiments the lethal sensitivity and speed of effectiveness in killing of ultraviolet radiation was studied. Cultures of green algae (*Chlorella vulgaris*) were grown on glass plates covered with agar. These plates were placed in special holders and exposed to the spectral lines of a quartz mercury-vapor lamp. The intensities of these different lines, ranging from 2250A to 3022A, were carefully measured and their effects on the algae noted. The lethal action was easily detected. Where such radiation fell on the plate the dead algae stood out in sharp contrast with the living. From careful measurements of plate densities and correlation of these data with wave-length intensities and durations of exposure, the radiotoxic spectral sensitivity was calculated.

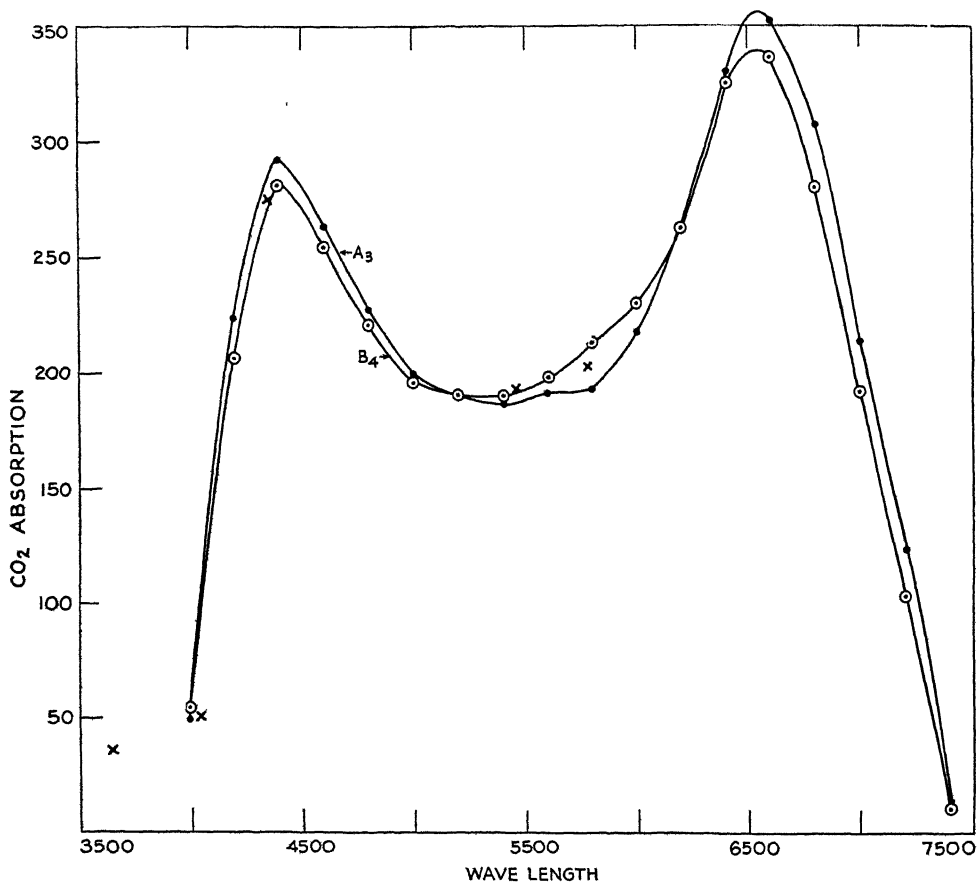
For this and other work in which the effects of illumination on growth and metabolism are quantitatively studied, it is necessary to record accurately the intensities and to know the characteristics and limitations of the radiation involved. Hence, a considerable amount of the Division's research has been in the field

SPECIAL EQUIPMENT

USED FOR THE SPECTROGRAPHIC DETERMINATION OF MINUTE QUANTITIES OF CARBON DIOXIDE.

of physics. For example, an absolute measure of the energy in the lines of the mercury-arc spectrum was needed in greater detail than was available in the literature at that time. Measurements were made on five different Cooper-Hewitt 220-volt D.C. quartz arcs, covering the region 2100A to 7000A. Two Bausch & Lomb quartz monochromators were used singly and also in tandem as a double monochromator. The observations were made with a single-junction vacuum thermocouple provided with a quartz window. The absolute measurements of the intensity of 32 of the more intense lines in the visible and ultraviolet spectrum of the quartz mercury arc were made and the results published.

The problem of securing monochromatic light of high intensity is one that continually confronts the physiologist dealing with light-growth responses. The possibility of using the Christiansen light filter was thoroughly investigated and reported in published form. This excursion into physical optics set forth an improvement in the construction of the filter and pointed out its advantages and limitations for general usage. Although some use was made of these filters,



WAVE-LENGTH ASSIMILATION CURVES

A_3, CORRECTED FORM OF CURVE OBTAINED WITH LARGE CHRISTIANSEN FILTER; B_4, THAT OBTAINED WITH SMALL CHRISTIANSEN FILTERS. X POINTS OBTAINED WITH LINE FILTER AND QUARTZ MERCURY ARC.

the problem of obtaining a high intensity monochromatic light still remains unanswered for many practical purposes.

In much of the earlier quantitative investigations on photosynthesis, algae were used as test plants. In the Division's laboratories new techniques for studying this vital subject were devised and applied to higher plants such as wheat seedlings. The plants were grown under controlled artificial conditions and the carbon-dioxide determinations made by a conductivity method in which this gas was completely absorbed in a standard KOH solution Later, an infrared spectrographic method for the determination of carbon dioxide was developed. This method is unique for its speed and sensitivity and has the additional merits of being independent of water vapor and of having but small pressure and temperature corrections. Furthermore, the air can be circulated continuously over the plants without any loss in the process of analysis. The method has been further improved by the addition of a photographic recorder. The sensitivity at normal air concentration is in the neighborhood of 1 part CO_2 to 1,000,000 parts of air. Without any great loss in sensitivity, measurements may be made in a fraction of a second.

Data obtained from one set of experiments showed the assimilation of carbon dioxide by young wheat plants over a wide range of carbon-dioxide concentrations and light intensities. Linear variation of assimilation with carbon-dioxide concentration in the presence of excess light was observed over a limited range. Linear variation of carbon-dioxide assimilation as a function of light intensity for excess carbon-dioxide concentration was also observed over a limited range. The transition range between the two regions of limiting factors was more extensive in these plants than in algae.

In another series of experiments the rate of photosynthesis based on equal incident energy was determined as a function of the wave length of light for young wheat plants. From this work it was concluded that the entire visible spectrum is effective in photosynthesis. Although not accurately determined, the wave-length limits appear to be between 7200A and 7500A on the long wave-length end of the spectrum and less than 3650A on the short wave-length end. There appears to be a principal maximum at 6550A in the red and a secondary maximum at 4400A in the blue. Increased reflection and transmission of radiation in the green region by the leaves of the plants diminished the effectiveness of light in this region to promote photosynthesis

By making use of the spectrographic method of determining carbon dioxide a most important series of experiments was carried out. It was demonstrated that much of the previous work on the time course of photosynthesis with algae was verified with young wheat plants. It was also shown that in flashing light a minimum of carbon-dioxide assimilation was found between 15-second periods and continuous light, with an increase in assimilation efficiency with increased frequency of intermittency. Emphasis should be placed on the importance of other studies of the induction period as a method of obtaining further information on the mechanism of photosynthesis.

PERHAPS the best way to summarize the activities of a research organization and obtain an idea of the field covered in its work is to examine its publications. Here are set down the results of its work. However, such an examination is like examining a seed. It is impossible to judge the size of the harvest from the size of a seed. Undoubtedly some seeds will yield fruit whereas others will not. A true estimate cannot be made until the

end of time, for, like seeds, one piece of scientific research begets another. Nevertheless, some information as to the general trend or direction the research of the Division of Radiation and Organisms has taken may be obtained from the titles of its publications Such a list is rather long, but a few of the more important articles have been appended to this brief article.

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THE HUMAN BLOOD FLUKES

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MUCH has been written on the "blood flukes," most of it scattered through medical journals. This little paper is an effort to bring up to date in an abbreviated form the information now available and to present this in nontechnical language to render it available to the interested general reader.

How important to humanity these parasites are is well illustrated by Faust's statement that in China alone 100,000,000 persons may be afflicted with schistosomiasis,[1] and that is only a little part of the world infested with schistosomes.

Science as a rule progresses with a slow and steady pace, adding increment to increment to produce the results apparent at any period. Now and then, however, stresses and strains like our recent war change the slow pace to saltations, and this has been the case in our understanding of the maladies known as schistosomiasis.

It would be interesting to have an exhaustive historical research on this topic; it might reveal the presence of the malady at the cradle of our civilization in the valley of the Nile. Yea, it seems even likely that the malady existed prior to man's existence and that he then, as now, became simply one of many mammals afflicted with this plague. That this is not an idle dream is indicated by Ruffer's[2] finding of calcified eggs of *Schistosoma hematobium* in mummies of the twentieth dynasty (about 1250–1000 B.C.).

Considering that our knowledge of man and his ills in early times centered largely about the eastern rim of the Mediterranean, one might naturally expect that the sum total of our knowledge would find its greatest expression in these regions; this, however, unfortunately is not the case. In the case of schistosomiasis, credit for the major unfolding of our knowledge of the subject must go largely to the researchers of Japan and more recently those of China, ably followed and assisted by the white man.

As known today the genus Schistosoma contains three species that are of prime importance as parasites of man, namely *S. hematobium* Bilharz 1852, *S. japonicum* Katsurada 1904, and *S. mansoni* Sambon 1907. To these, four additional species which have occasionally been reported as parasites of man must be mentioned. They are *S. bovis* Sonsino 1876, *S. spindalis* Montgomery 1890, *S. incognitum* Chandler 1926, and *S. intercalatum* Fischer 1934.

Schistosomes are members of the phylum Platyhelminthes, popularly known as "flatworms." This phylum embraces the dorsoventrally flattened, bilaterally symmetrical worms that do not have a true coelomic body cavity.

The phylum embraces three classes:

1. Turbellaria, which contains the nonparasitic, externally ciliate, free-living members.
2. Trematoda (flukes), embracing the flatworms possessing an alimentary canal and no external cilia in the adult stage.
3. Cestoda (tapeworms), whose members are also parasitic and nonciliate but lack the alimentary canal.

The schistosomes are members of the class Trematoda, which embraces several subclasses. One of these, Digenea, contains all the human parasites. The Digenea have one or two suckers, the anterior being always single and median.

[1] Earl Baldwin McKinley. Geography of Disease, *Am. J. Trop. Med*, 15, Suppl., 432.

[2] Ruffer, *Brit. Med J.*, 1910, 1, 16.

They pass through a complex development, embracing both sexual and asexual generations in different hosts.

Of the various orders of Digenea, schistosomes belong to the Prosostomata, which have the mouth at the anterior end of the body, usually surrounded by a sucker.

Schistosomes belong to the suborder Strigeata, some of whose members are hermaphroditic; others have the sexes distinct. They are parasitic on vertebrates in the adult stage, and the cercarial stage has a bifurcate tail.

To this suborder belongs the superfamily Schistosomatoidea, which embraces the blood flukes and among these the family Schistosomatidae, in which the sexes are distinct. In the adult stage these live in warm-blooded vertebrates.

Tabulating all this, to place the genus in its proper niche in the animal kingdom, we have:

Phylum Platyhelminthes
Class Trematoda
Subclass Digenea
Order Prosostomata
Suborder Strigeata
Superfamily Schistosomatoidea
Family Schistosomatidae
Genus Schistosoma

To fully understand the problems connected with the control of schistosomiasis, it becomes necessary to inquire into the complete life history of the parasite with the hope of finding somewhere a loose rivet in its armament or an unprotected vulnerable heel.

The Life History of Schistosomes

Although the malady produced by Schistosoma was long known, the complete life history of the organism has been unraveled comparatively recently, i.e., that of the members parasitic upon man. Of these, that of *Schistosoma mansoni* appears to have received the most exhaustive scrutiny. I shall therefore give a brief epitome of its ontogeny.

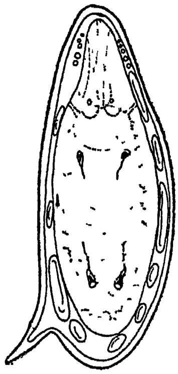
Schistosoma mansoni. The eggs, discharged with the feces of its host, are oval in shape and bear a lateral spine (Fig. 1). In measurement they range from 114 μ–174 μ in length and 45.6 μ–68.4 μ in diameter, averaging 164 μ by 70 μ. When discharged they have already undergone development that has carried them through the early cleavage stages to a well-developed miracidium. The miracidium is very active in the egg when mature. Hatching occurs over a period of 48 hours after the egg reaches water. Faust and Hoffman found that the most suitable water for the hatching and further progress of the miracidium was that secured from the source from which their intermediate molluscan host (Australorbis) was obtained, i.e., water having a pH between 7.3 and 8.1, and that tap water and distilled water registering a pH below 7 were much less satisfactory. Miracidia will remain viable in feces for two to three days at a temperature of 75° to 90° F.

The Miracidium. The miracidium is an oval animal having 21 dermal plates arranged in four series, which from the anterior posteriorly have 6, 8, 4, and 3 plates, respectively (Fig. 3). These plates bear the cilia that propel the organism through the water. The anterior end is cone-shaped, and the spaces between the plates are devoid of cilia.

PLATE I (OPPOSITE)

All these figures of *Schistosoma mansoni* have been copied from Faust's *Human Helminthology* and Faust and Hoffman's "Studies on Schistosomiasis in Puerto Rico."

1. Egg; 2. Dermal plates of miracidium; 3. Miracidium; 4. Cercaria; 5. First generation sporocyst; 6. Second generation sporocyst; 7. Adult worms.



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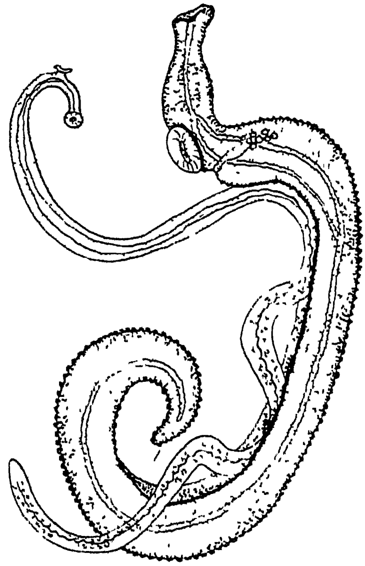

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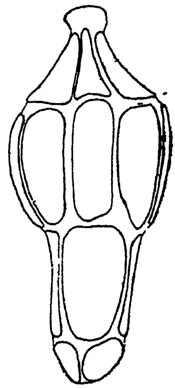

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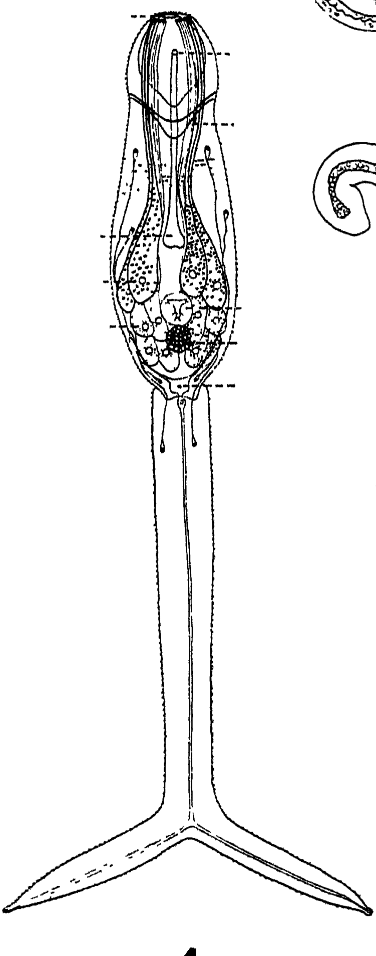

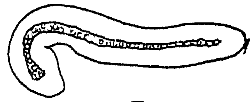

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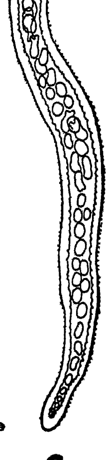

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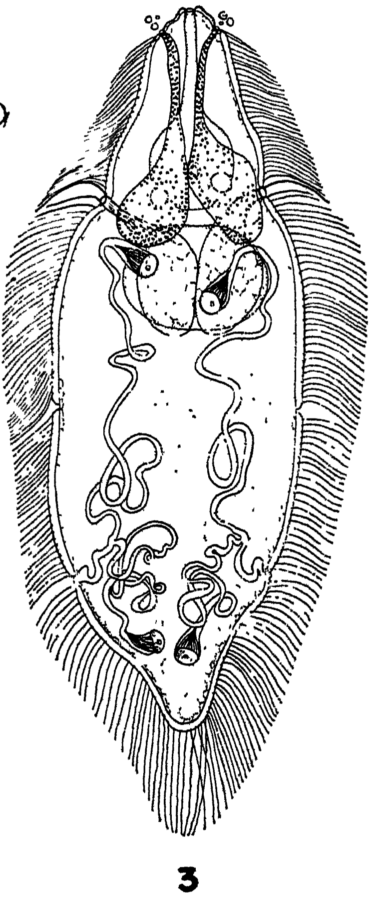

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Beneath the dermal plates of the free-swimming miracidium an epithelial layer and delicate longitudinal and transverse muscle cells are present, the latter being responsible for the changing of the shape of the organism. Within the miracidium there has been recorded (Fig. 3) a large flask-shaped cell whose long neck extends to the center of the head cone. On each side of this is a single retort-shaped anterior secretory gland which discharges into the side at the base of the head cone. These glands give an acidophilic reaction and are believed to secrete the fluid assisting in the penetration of the molluscan intermediate host. Posterior to these glands is the nerve mass, and just below it are the lateral secretory glands, composed of a number of cells with basophilic reaction. These discharge laterally at about the middle of the major part of the anterior gland cells. The excretory system consists of an anterior and posterior pair of flame cells, connected by more or less coiled collecting tubules that discharge on the side of the animal near the anterior end of the posterior fourth. The miracidium thus equipped is ready to seek its molluscan intermediate host. Free miracidia have less than a 24-hour life span in which to accomplish this.

In America mollusks of the genus Australorbis and Tropicorbis have been found to serve in this capacity. In the Old World members of the genus Afroplanorbis perform this function. (Quite a number of mollusks not Planorbid have been cited by some authors as intermediate hosts of *Schistosoma mansoni*, but it is now believed that that citation was due to insufficient discrimination of the Trematode species involved.)

When a miracidium comes near its proper intermediate host it at once heads for it, probably attracted by some secretion of the mollusk. It then burrows into the host, aided by the cilia and the secretion of the anterior glands. The penetration appears to require but a few minutes. The tentacles and head parts of the snail appear to be the preferred points of attack.

Once within the mollusk, migration toward the esophagus and digestive gland takes place, and here the next two stages occur. Shedding the ciliated plates, the miracidium undergoes profound internal changes. The digestive, neural, and glandular structures are resorbed, and in the first sporocyst stage the organism becomes an elongate oval bag functioning as a brood pouch for the development of the daughter sporocysts, the second sporocyst stage. These are developed from the germinal epithelium lining the cyst (Fig. 4). Some 20 to 25 of the second generation are produced by the parent cyst.

The daughter cyst, or second generation, differs materially from its parent (Fig. 5). It has a more elongate wormlike body covered with spinose epithelium. The anterior end is snoutlike and covered with spines. The interior consists of germinal epithelium which develops "germ balls" that gradually, progressively evolve into cercaria. Hoffman has calculated that many tens of thousands of these may result from the infection of a single miracidium. The actual number produced in the case of multiple infections of the snail depends upon the life span of the snail and its powers of endurance. As in the case of the first sporocyst stage, the cercaria break through the body wall of the cyst and pass into the lymph spaces about the digestive tract, passing through the body wall into the water.

The Cercaria. The free-swimming cercaria is a curious creature. It might be likened to a tadpole with a forked tail. The anterior end, or body, of the animal is a depressed oval, separated from the longer, caudal, portion by a decided constriction. The terminal por-

tion of the tail is developed into a bifurcate swimming organ. The entire exterior of the body is beset with minute spines. An oral and a ventral sucker are present. Faust and Hoffman give the following measurements of fixed specimens as follows:

	Range (μ)	Mean (μ)
Length of body	185–230	214
Breadth of body	75–110	92
Length of tail trunk	185–300	225
Breadth of tail trunk	60–75	68
Length of caudal furci	90–130	104

Two pairs of large, granular, flask-shaped acidophilic glands, situated immediately in front of the ventral sucker, and four pairs of small, finely granular, basophilic glands behind the anterior glands are present.

Four pairs of flame cells, three in the body and one in the anterior part of the tail, discharge their products through paired collecting tubules into a common bladder, which empties through a tube at the end of the flukes of the tail. (For a sketch of these structures see Figure 6 which is copied from Faust's *Human Helminthology.*)

Faust and Hoffman found that cercaria bore through the skin of the mammalian host in one hour, sometimes in ten minutes or even less. They are aided in this by the lytic action of the glandular secretion as well as by the mechanical burrowing efforts of the animal. It is this phase that produces the dermal itching symptoms in the mammalian host. In this process of penetration the cercaria shed their tails. They are said to reach peripheral venules of the skin within 22 hours and from there are carried to the right heart and thence to the lung; from the lung they are carried to the left heart and thence by the systemic circulation over the body. Those that successfully reach the portal vessels will grow and mature sexually and finally migrate to the mesenteric plexus, where they mate and produce eggs. (Faust has given a very detailed account of this process in the case of *S. japonicum.*[3])

The adult worm (Fig. 7) may be briefly described as follows: The adult *Schistosoma mansoni,* as well as all the human blood flukes, have the sexes distinct. The male is shorter and broader and stouter than the female and has the sides approximated ventrally to form a tube in which the adult female is encompassed. The male *Schistosoma mansoni* measures 10 mm.–12 mm. in length and is beset with fine tubercles. It has two suckers, the anterior being terminal; the ventral is about one-sixth of the length of the animal behind the oral sucker. The mouth is in the oral sucker. The esophagus, beginning at the oral disc, is surrounded by glands and reaches to the ventral sucker, where it divides into paired ceca which extend to the middle of the body. There they unite to form a winding tube that ends blindly near the posterior end.

The reproductive system of the male consists of eight to nine testes with ducts leading into a *vas deferens* and seminal vesicle which discharges through a genital pore near the ventral sucker. The nephridial system consists of flame cells, whose products are passed by slender tubules into the paired collecting tubules; these convey the excretions into a bladder at the posterior extremity, from which they are discharged through the excretory pore.

The female is filiform, measuring 12 mm.–16 mm. in length. The papillae on the surface are confined to the two ends. The ovary is in the anterior half of the body, and the vilellaria occupy three-fifths of the posterior part. The uterus is short and usually contains one or only a few eggs. The eggs are passed through the oviduct to the shell gland, where they receive the yolk substance, brought

[3] *Am. J. Trop. Med.*, 1946, **26**, 113–14.

here through the slender vitelline ducts. Here also the eggs are fertilized and receive their shells before they are passed into the uterus, from which they are eliminated through the genital pore. They bore their way from the small veins into the intestine of the host by means of the spine and lytic secretions.

In *Schistosoma mansoni* they are normally eliminated with the feces. Those of *S. hematobium* and *S japonicum*, on the other hand, are voided with the urine.

The anatomic structures of the various developmental phases of *Schistosoma hematobium* and *Schistosoma japonicum* are not unlike that of *Schistosoma mansoni* but sufficiently distinct in almost all phases to require separate naming.

The Molluscan Intermediate Hosts. Since a large part of the schistosome's life is spent in some fresh-water mollusks, it becomes desirable to know the species involved in this capacity. An intimate knowledge of the habitat and habits of the intermediate host may reveal ways and means for eliminating the mollusk, thereby removing links from the chain that constitute the life cycle of the worm and thus exterminating it before it can reach man.

It has now been well established by experiment that only members of the genus Australorbis and Tropicorbis of the family Planorbidae serve in this capacity in America for *Schistosoma mansoni*. The experiments of Wright, Cram, and Jones, of the National Institute of Health, have shown that none of the many other species and genera of this family tested is susceptible to infection.

In Africa members of the genus Afroplanorbis, a group closely related to Australorbis, serve in the same capacity.

The known distribution of schistosomiasis in America is spotty, and that of the intermediate hosts appears equally interrupted. This seeming discontinuity may be owing to our incomplete knowledge of the occurrence of the necessary mollusks as well as that of the parasite. We do know, however, that in endemic centers of schistosomiasis the necessary intermediate host is always present.

Peripatetic, roving man may carry the infection from place to place, and only if he is careless in the disposition of his waste products in the places where suitable mollusks are present will he become a focal point for new infections. Education in sanitation, particularly the elimination of human wastes, among unenlightened primitive people, therefore, constitutes the best approach to the elimination of this and other maladies. Unfortunately, we know only a little about the other mammals also subject to infection. The elimination or curtailment of the disease where it is not restricted to man, as, for example, in *Schistosoma japonicum*, presents a much more difficult problem, probably best approached through the elimination of the intermediate molluscan host. To accomplish this it becomes necessary to know the ecologic conditions under which the mollusks in question can exist.

The adjustment of fresh-water mollusks to hydrogen ion concentration was

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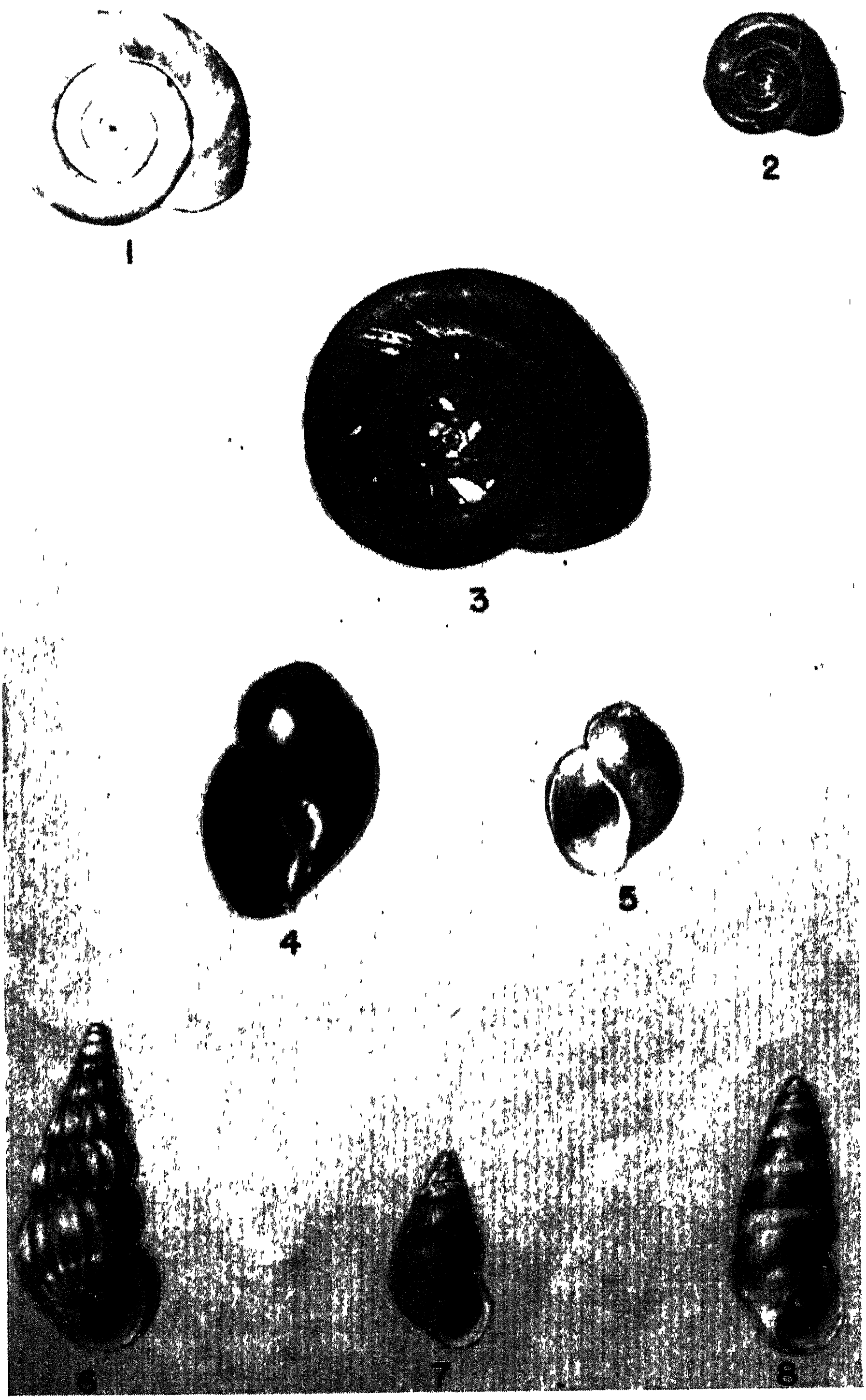
PLATE II (OPPOSITE)

These figures depict representatives of the various genera that serve as intermediate hosts for human schistosomes. Figures 1–5 have been enlarged to double natural size; figures 6–8 five times.

1. *Afroplanorbis boissyi* (Michaud); 2. *Tropicorbis orbiculus* (Morelet); 3. *Australorbis glabratus* (Say) [=*A. guadaloupensis* (Sby)]; 4. *Physopsis africana* (Krauss); 5. *Bulinus truncatus* (Michaud); 6. *Oncomelania hupensis* (Gredler); 7. *Schistosomophora quadrasi* (Möllendorff); 8. *Katayama nosophora* (Robson).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first brought to my attention many years ago at Washington, D. C., where I noted that the Potomac River harbored certain species which were not found in its side streams. The explanation for this was the fact that the Potomac waters, thanks to the contribution of the Shenandoah's limy waters, were slightly alkaline in reaction, whereas the side streams, fed by springs charged with organic acids (tannic, humic, succinic, etc) furnished by decaying vegetation, yielded an acid reaction. Hence, a decided difference in environment is responsible for the distribution of their molluscan fauna.

This same state of affairs I found in my explorations for mollusks in the West Indies. This can be best visualized by describing an experience I had on the island of Grenada. This high island of the Lesser Antilles is covered with forests and plantations of cacao, bananas, oranges, nutmeg, and sugar cane. The soil being noncalcarious, excepting a coastal strip which represents an elevated coral reef on the Atlantic side. nowhere in the streams coming from the mountains did I find Australorbis or Tropicorbis. In the coastal plain of the northeast corner of the island is a place called Mineral Springs. Here a number of small springs well up through the limestone. These form pools of varying size and join to form a small stream. This water coming up through the limestone reef is alkaline. Here I found Australorbis and a host of other mollusks flourishing amid masses of blue-green algae in such abundance that I filled my half-bushel collecting basket in no time. This faunula extended for a space of a few squares; then the streamlet joined a mountain brook, which terminated its molluscan distribution like a screen. The mountain stream, like all the high mountain streams that I examined in this and other islands, was acid in reaction, therefore unsuited for the calciphilic Australorbis and Tropicorbis.

Later I found the same but much more extensive fauna in the streams of the limestone mass on the bay side of the island of Trinidad, whence the ancestors of the Mineral Spring mollusks had evidently been carried as eggs or young to Grenada, some 130 miles distant, on the feet of migrating water birds.

Australorbis guadaloupensis (Say) took its name from the island of Guadeloupe. The name Guadeloupe has been used to embrace both Guadeloupe proper (Basse-Terre) and Grande-Terre. I found no Australorbis on Guadeloupe proper, but on Grande-Terre, which is an elevated limestone mass, they were present in great abundance. Here the natives dam off valleys to hold the water during the rainy season. These slightly alkaline pools furnish the water supply of the region and are literally paved with the living and dead shells of Australorbis. Here the natives come for water with their empty five-gallon kerosene cans. The shores of some of the most populous places I found strewn with human feces. If the individuals contributing them were carriers of *Schistosoma mansoni* and rain washed the fecal material into the ditch, there would here be an ideal condition for the establishment of an endemic center. Natives are proverbially careless in the deposition of their wastes.

Another place where conditions were found to be ideal for schistosomiasis was on the island of St. Christopher. I shall quote from my journal (1929, p. 40):

> Instead of stopping at Monkey Hill, which I found to be barren and uninviting, we went to the next mountain and collected on the Fountain Estate owned by Mrs. Barkley. Not far from the house I found a narrow gorge choked with tropical vegetation: palms and treeferns, many araceous things, rose apples, etc., etc.; and a babbling brook tumbling over many cataracts and expanding into many small pools literally teeming with *Australorbis guadaloupensis* of which I gathered about five hundred. Many years ago the African gray monkey, *Cercopithicus*, was introduced here and has found a very

suitable home with no enemies except man. I saw several of them cautiously eyeing me from afar and swinging away into dense cover after having given me the once-over.

This combination of monkey and Australorbis is not only interesting but important, because the monkeys are known to harbor *Schistosoma mansoni.* I was told by the resident doctor that the intermediate host was not known on the island. I should not like to bathe or drink from this stream which supplies the Fountain Estate and part of Basse-Terre with water. The monkeys probably become infected by drinking the water. The boys with me said that the monkeys ate the mollusks, which may be true.

Dr. S. B. Jones, resident physician of St. Christopher, has estimated that 25 percent of the inhabitants are infected. (The 1911 census cited 26,283 inhabitants.)[4]

In the West Indies Australorbis is known in Jamaica, Haiti, Dominican Republic, Puerto Rico, Culebra, St. Christopher, Nevis, Montserat, Antigua, Grande-Terre (Guadeloupe) Marie-Galante, Martinique, and Trinidad.

Having only a two-masted sailing vessel at my command, I did not risk cruising along the dangerous ironbound Atlantic side of the Lesser Antilles. I was therefore able to explore only such portions as could be reached by overland trips. It is quite likely that future explorations may reveal Australorbis in parts of the Atlantic coastal strips such as that described for Grenada. On the mainland Australorbis ranges from Venezuela to Argentina.

The nearly related genus, Tropicorbis, some members of which have been found by Wright, Cram, and Jones to be subject to *Schistosoma mansoni* infection, ranges even farther than Australorbis. The U. S. National Museum contains specimens from the mainland from Louisiana, Texas, New Mexico, Mexico, Yucatan, Venezuela, Nicaragua, British Guiana, Brazil, Argentina, Uruguay, and Chile; in the islands we have it from various places in the Bahamas, Cuba, Isle of Pines, Jamaica, Haiti, Puerto Rico, Antigua, Barbados, and Trinidad. There is a possibility that all the species involved may serve as intermediate hosts for *Schistosoma mansoni.*

In Africa and adjacent territory members of the genus Afroplanorbis serve as intermediate hosts of *Schistosoma mansoni.* The species of this genus range through northern and central Africa. The scant information at hand indicates that this genus, like Australorbis, lives in an alkaline habitat.

In their adjustments to intermediate hosts we find great differences. *Schistosoma hematobium* and *Schistosoma japonicum* require mollusks living in a slightly acid habitat. *Schistosoma hematobium* is partial to mollusks belonging to the family Bulinidae, the subfamily Bulininae of which the species of the genera Bulinus and Physopsis have definitely been implicated.

In Portugal some Planorbis have been listed as furnishing an intermediate host. This conclusion should be re-examined. It is more likely that the worm implicated was *Schistosoma mansoni.*

Schistosoma hematobium has been reported from Egypt, Asia Minor, South Africa, East Africa, Morocco, and Portugal.

Schistosoma japonicum ranges from Japan south through the Philippines to Celebes and on the mainland from China to Siam.

The known mollusks involved as intermediate hosts of this species belong to the family Hydrobeidae and the subfamily Hydrobeinae and are embraced by the genera Katayama, which ranges through Japan and China; Oncomelania in China; and Schistosomophora in the

[4] *J. Trop. Med. and Hyg.,* 1922, 25, 25–27; 1923, 26, 243–254; 1931, 35, 129–36.

Philippines and China. No members of these genera are known from Celebes and Siam. It is possible that the cases reported from there were in human immigrants from China and that the disease has not become established there for want of a proper intermediate host.

While not all species of the genera listed have been definitely implicated, it is most likely that they will serve as intermediate hosts when and where opportunity occurs.

I have refrained from discussing the medical phase of this subject or even citing titles of papers thereof for that would require more printed pages than have been allotted to me. That phase of schistosomiasis must be looked for in medical textbooks and in medical journal literature.

My suggestion for elimination of the molluscan intermediate host would be to crush limestone and scatter this in places found to contain the intermediate hosts of *Schistosoma hematobium* and *Schistosoma japonicum,* which field tests have shown to be slightly acid in reaction. Yoshida, at my suggestion, put this in effect in Japan with good results. The control of the intermediate host of *Schistosoma mansoni* presents a more difficult problem since these mollusks are addicted to alkaline waters. Copper salts of various kinds have been employed in concentrations not detrimental to human beings or household animals, with some success. It is possible that some of the newer toxins such as DDT and the many others now undergoing tests may prove useful and efficacious.

SONNET ON KNOWLEDGE

Petal by petal shall the flower unfold
To lay its fragrance on eternal day—
The blue of lupine, the rose in her array,
Nasturtium's August fires, the marigold . . .
We see a chart of miracles unrolled—
That daffodils should rise from frozen clay,
Black dogwood whiten into ocean spray,
And ferns uncurl from out a wet leaf-mold!

So is the Mind-of-God an opening flower . . .
O blazing lily of a night of stars!
O angel wings beyond the mortal range!
Though knowledge like a gathering storm may lower,
A bud unfolds—of atom, moon, or Mars—
A luminous bloom of heaven, bright and strange!

BARBARA WHITNEY

Winner of the Virginia Lyne Tunstall Prize for a Petrarchan Sonnet.

THE RISING QUALITY OF NEW WORLD ARCHEOLOGY*

By NEIL M. JUDD

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THOMAS JEFFERSON was merely satisfying his curiosity when he opened a low earth mound near Charlottesville, Va., in 1780. His surprise probably equalled that of his Negro slaves when the contents proved to be a thousand Indian skeletons.

Caleb Atwater, in 1819, was the first to attempt a general account of the diversified Indian mounds in Ohio. In the very first volume of that famous series "The Smithsonian Contributions to Knowledge" Squier and Davis in 1848 undertook to describe and explain the ancient monuments of the whole Mississippi Valley.

Because certain Mississippi Valley mounds outwardly resembled pyramidal structures they had seen far to the south, Squier and Davis believed all were built by a tribe closely related to the highland peoples of Mexico, Central America, and Peru.

William Bartram, the American naturalist, noted many earth mounds, both large and small, during his travels throughout the southeastern states. Because he could not believe that local Indians had either the ability or the energy to construct them, Bartram attributed those mounds to an extinct race, the "Mound Builders."

Since the American Indians, like the Jews, were divided into tribal groups they became the "Lost Tribes of Israel" to many a credulous person. Others were equally positive of a Danish or Welsh origin. The myth of a submerged Atlantis, first recorded by Plato nearly four hundred years before Christ, still has its unyielding adherents, although recent years have brought forth a Pacific rival, the "Lost Continent of Mu."

These fictions and diverse surmises, however naive they may seem to most of us, represent a definite period in New World archeology, the period in which speculation substituted for fact.

One of our cherished American privileges is that of free speech. And we have heard more gratuitous expressions on archeology than on any other subject except politics. Personal opinions, however, are not all of equal worth. The man leaning across the fence as a Diesel-drawn train rockets past may have positive ideas on its operation, but the one actually at the controls can speak with greater authority. He has the background in training and experience that provides substance for an opinion.

But let no one frown on the man with imagination! Imagination is the spark-plug of archeology. It starts the engine and keeps it going. Together, imagination and intuition have retrieved dead civilizations from their rubbish heaps and crumbled masonry; together they have recreated the lives of peoples nameless in history. It was a combination of intuition and imagination based on long experience that identified the site of ancient Ur and peeled its successive foundations one from the other.

Consciously or unconsciously, each generation learns from its predecessors, and we of the present are not exceptions. We have learned by being critical of our teachers and by seeking to improve upon

* Address of the retiring president, 44th Annual Meeting, American Anthropological Association, Philadelphia, December 28, 1945.

their methods. Some were too imaginative; some misinterpreted the simple facts before them, at least from our point of view. But the majority erred only in treating their subject matter a little more broadly than is the practice today. Theirs was descriptive rather than analytical research.

I have heard one of the stalwarts of the last generation criticized for failure to recognize the ceramic complex on which southeastern archeologists now lean so heavily. The speaker seemed quite unmindful of the fact that the object of his censure had died five years before that complexity was first created. Until our younger students pointed out its internal and external differences, southeastern pottery offered no problem.

The current tendency in every walk of life is toward specialization. We hew to a finer line. The old-time naturalist is now a rare bird. Gone is the day of the general practitioner! Even the archeologist limits his efforts, say, to the Eastern Woodlands, the Maya Area, or the Peruvian Coast.

In focusing upon an ever-diminishing field of inquiry, archeologists of the Western Hemisphere have gradually altered their concept of archeology and their approach to it. Closer observation and a careful weighing of elements previously thought unimportant are among the desiderata today.

One of the parent organizations of the American Anthropological Association is the Anthropological Society of Washington, founded in 1879. The title of the address at its first formal meeting was "Relic-Hunting." At a recent meeting of the Society the subject of discussion was a proposed organization exclusively for professional anthropologists. You see what advances we have made in sixty-odd years! Henceforth, if not illegal, it will be positively immoral even to hunt arrowheads without a doctorate.

Within sixty years the prime purpose in American archeology has completely changed. Recovery of history, prehistory, is the object now. No longer does one condone pot-hunting under the guise of science. In seeking to reconstruct the culture of an extinct people, it seems most logical to proceed from the known to the unknown; to begin with the earliest written record and work backward. I will not pretend that institutional relic-hunting has wholly disappeared or that every field worker concerns himself with painstaking examination of his findings but, in both respects, there has been marked improvement even within the brief span of my own observation.

In the old days archeological problems were solved by fiat and by table pounding. You can't do that now! Now you must have facts. You have got to have what we in the profession call "data." You should rely upon stratigraphy and tree-ring dates whenever possible. You must concoct a distinctive designation for every local variation in pottery. You must determine the dominant types and you will get nowhere at all unless you can figure trait percentages.

One of the first positive efforts toward improved techniques was made in the southwestern United States some thirty years ago. A few young investigators were then giving thought to sequential developments in Anasazi culture. The stratified deposits of old village dumps contained incontestable proof. From that experimental beginning the stratigraphic method gradually evolved and, with improvements, has since become a thoroughly dependable procedure. Its influence has been felt wherever American archeologists are engaged with field work.

Culture variations and sectional differences are now generally recognized. Local preferences in art, architecture, and the tools of industry have been disclosed. Food habits have been indicated

here and there and pre-Columbian commerce demonstrated by the finding of objects far from their place of origin. Dendrochronology, wherever applicable, has provided a measure for prehistoric time more accurate than that available to archeologists elsewhere in the world.

Under the more precise methods now current, archeology has everywhere made noteworthy advances. The antiquity problem has been under scrutiny again; new evidence conclusively proves the contemporaneity of early American Indians and extinct mammals commonly accredited to the late Pleistocene. Comparable evidence forty years ago was shouted down because geologists, paleontologists, and archeologists had not yet learned to cooperate on problems of mutual interest. Too, the rugged individualists of the last generation did not trust one another's judgment in matters of antiquity.

Investigators in Mexico and Central America have brought increased order and understanding to the pre-Spanish history of their respective countries. Eventually this whole fascinating tangle will be unraveled and each thread traced to its point of origin. Then, perhaps, we shall know what preceded the "Archaic"; we may even find trace of those trail blazers first, theoretically, to funnel through Panama.

Stratigraphy has again played an important part in clarifying the archeological picture in South America. Here representatives of the Institute of Andean Research have joined forces with local authorities on ten major projects between Venezuela and Chile. These were planned primarily as fact-finding expeditions; excavations were largely restricted to testing trash piles at carefully selected sites. The purpose was to isolate, insofar as possible, the basic cultures of the area and to trace their interrelationships. The early harvest of this cooperative undertaking includes stronger bonds between archeologists in the participating republics and no fewer than twenty-two separate papers reporting their observations. Excavations at Cuzco provide our first factual picture of Inca civilization at its height.

Among the many that might have been cited, these few examples will suffice to illustrate my point, namely, that New World archeology has risen in quality directly in proportion to the dependence of its reporters upon precise data. There is a great deal more to archeology than digging relics. Trait lists, diagnostic types, analyses of diverse items, the identifiable remains of birds, beasts, and plant products—all these, and more, provide the detailed information necessary to the successful reconstruction of a prehistoric culture.

These reconstructions, of course, are not complete and never can be. They are based for the most part on imperishables such as stone, bone, and pottery. Knowledge of things that decay—fabrics, basketry, tanned hides—must be inferred or deduced from charred remnants, chance imprints, and the existing flora and fauna of the district. One must guess at the social system represented and its esthetic values.

That the quality of New World archeology has improved through attention to particulars previously neglected is less a reflection upon our immediate predecessors than upon the period in which they lived and worked. A generation ago museums gauged the success of field parties by the bulk of material recovered. Today major effort is directed toward the intangible. Experience proves that those expeditions which have contributed most to knowledge have been carefully planned in advance, have continued over a period of years, and have enlisted the aid of workers in other disciplines. Rarely can one dash out for a few weeks and return with anything worth while by current standards. Museums still

want specimens, to be sure, the better to illustrate advances in knowledge and thus fulfill their mission in public education. But the collection, as such, is no longer the principal objective of leading research institutions.

Progress always seems snail-slow when measured too soon. True perspective is best gauged from a distance. And so it is with archeology in the New World—those of us who have been in it a long while can see the rise in the quality of field work that began when emphasis first turned from specimens to their associated data.

AND where do we go from here? For one thing, I anticipate a slower pace for a time. I believe we have advanced too far too fast. I believe the balance will soon tip the other way again, that we will become a little less "scientific." The diverse elements that go to make up a given culture complex will be weighed without bias; research reports will be written with less parading of ponderous verbiage than echoes from some quarters today. We will probably display more caution in analysis and classification. For example, a recent study sets up, among others less conspicuous, five new pottery types on the basis of, respectively: 1 complete vessel and 7 sherds; 1 vessel and no sherds; 2 sherds; 1 sherd; 2 complete vessels and 12 sherds. As type determinatives, such evidence looks pretty flimsy.

Much has been accomplished in the past quarter century and much remains to be done. There are still many questions to be answered, many puzzles to be solved. And there is salvage work to be done also. The vast reclamation and flood-control program now in prospect for every major river valley in the United States will bring ruin to thousands of Indian village sites, ceremonial units, and burial places. Their destruction will be complete and final. With them will go for all time the wealth of information that could have been saved had there been influential spokesmen in high places. Engineers and politicians building for tomorrow will not be delayed by yesterday's leavings!

LANGLEY

Pondering the buzzard's flight
A genius drew
The inspiration to translate
Man to the blue.

Now dreadful fruit of that ascent
Holds earth in dread.
He will not grudge the bitter laurels
From his silent head.

M. H. PALMER

ECOLOGICAL COUNTERPARTS IN BIRDS

By HERBERT FRIEDMANN

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In the present usage of technical language to express and to conceal the complexities of the animate world, its contents and its activities, its processes, past and present, and its interlocking patterns and coordinations, it is no longer fashionable to personify "Nature" and to attribute to it anything remotely resembling plan or feeling. However, there used to be current an old expression which, in spite of changing points of view, still conveys a truth of general validity, although its purely rhetorical construction may be considered in need of renovation: "Nature abhors a vacuum." The only reason this statement has a continuing validity is the fact that it is so difficult to find in nature a vacant niche, an untried method, or an unrelated, isolated, hence, "vacuum-surrounded," process. The thoughtful observer quickly comes to realize this state of affairs and, in the verbiage of an earlier generation, to conclude that Nature appears to have "tried everything" at least once.

When we come to more specific cases, when we limit our search to more strictly comparable materials and situations, we are often forced to the conclusion that frequently there is a repetitious sameness in the end results; that similar niches are often filled by convergently similar, but originally quite divergent, forms. The more complete our knowledge of any given group of organisms, the more such cases come to mind. In the present essay we wish to point out, merely as random samples, a number (but only a small part) of what might be termed striking ecological and morphological counterparts in a single vertebrate group—the birds.

It seems desirable to further restrict the survey to cases personally observed and studied in the field, in North and South America and in Africa. The instances cited below are of unequal value since the actual information available, as contrasted with the mere general impression received in the field, varies greatly and also since the cases are of different degrees of convergent similarity. Some of the cases are well known; others appear not to have been recorded previously.

Perhaps the "classic" case of this sort and, indeed, one of the most striking is the amazing similarity in appearance and in general habits of the American troupial genus *Sturnella* (the meadowlarks) and the African pipit genus *Macronyx*. Both are "unusual" members of their respective families as far as their coloration goes—the upperparts streaked blackish, brownish, and pale buff; the chin, throat, breast, and upper abdomen, bright yellow with a broad black pectoral band. The similarity is carried even to the white outer tail feathers in the two genera. Both *Sturnella* and *Macronyx* inhabit grassy open spaces; both make somewhat arched-over, or semidomed, nests of dry grasses on the ground; both have the habit of turning away (that is, of hiding their brightly colored underparts) from an approaching observer; both spread the tail, showing the white lateral feathers as they fly, and both have a somewhat melancholy whistling note. To make the case even more complete, one species of *Macronyx* (*M. ameliae*) has the underparts pinkish red instead of yellow, paralleling the red-breasted near relative

of *Sturnella,* the genus *Pezites* of South America, again a bird of similar habits.

The large family of weaver-birds (the *Ploceidae*) fills many ecological niches in Africa that are occupied in the Americas by some of the troupials (*Icteridae*), by some tanagers (*Thraupidae*), and by some of the finches (*Fringillidae*). There are in this assemblage numerous instances of close convergence in which the plumage patterns are remarkably similar and in which there are related similarities in habits as well. Thus, the males of the long-tailed weavers of the genus *Diatropura* have a nuptial plumage exactly paralleling that of the American red-winged blackbird (*Agelaius phoeniceus*) except for the greatly elongated tail feathers of the former. Both birds are uniformly and solidly black, with buff-edged red patches on their outer, lesser, upper wing coverts forming "shoulder patches" or "epaulets." Both indulge in essentially similar courtship displays—arching the wings, raising these red "epaulets" and bowing forward, although *Diatropura* also goes through a bouncing aerial dance over the female; both live in similar reedy, rather lacustrine, habitats. Both have marked sexual dimorphism, the females in both being heavily streaked in pattern. In *Diatropura* the black-and-red plumage is seasonal, whereas in *Agelaius* it is worn throughout the year. Weavers of the genus *Urobrachya,* closely related to *Diatropura,* but without the long feathers, also exhibit marked resemblances toward *Agelaius.*

Numerous African species of weavers of the genus *Ploceus* present general resemblances to many American troupials of the genus *Icterus,* the plumage pattern of various combinations of yellow or yellow-orange with black and white being repeated in different species of the two groups. Both genera have similar nesting habits of weaving their pendant nests from the terminal branches of sizable trees, although the weavers are more inclined to nest in loose colonies (that is, many nests in one tree) than are the troupials. Even though the two groups have somewhat dissimilar feeding habits, seeds being the main diet of the weavers and insects the chief source of nourishment of the troupials, the most casual observer would soon come to sense a decided similarity between them in their general appearance and in their actions.

A group of forest-dwelling weaver-birds of the genus *Malimbus,* unlike the much larger genus *Ploceus,* are red and black in color and are paralleled in the American tropics by a similarly sylvan genus of largely red-and-black tanagers, *Ramphocelus.* In their general appearance and actions the two have much in common, although their nests are quite dissimilar.

One of the small, somewhat "nontypical," genera of weavers, *Hypochera,* comprises a few forms, the males of which are solid, deep blue-black, with pale bills; the females, streaked brown and buffy. They are surprisingly similar in both sexes and in their young (juvenal plumage) to a South American finch, *Volatinia jacarini.* Both birds are largely terrestrial, procuring their food —grass seeds and seeds of low plants— on the ground, and both are given to using somewhat elevated perches when not feeding. Some twenty years ago I wrote in my field book the following, then fresh, impression:

> . . . . *Hypochera* seems the ecological as well as the visual counterpart in Africa of *Volatinia* of the American tropics, and it is rather surprising to find that both have a bouncing type of courtship display, similar call notes, and similar songs. In both the display is fairly primitive, there being no specialized feathers or other structures involved. The display is a bouncing aerial dance, the bird literally jumping or bouncing off its perch into the air several times. The whole display lasts about three seconds and is accompanied by a guttural, beady song, which is very jerky as though the rhythmic bounces of the bird interfered with its delivery.

Naturalists familiar with North American or European birds are accustomed to think of shrikes (*Laniidae*) as gray, white, and black birds of strictly carnivorous habits, feeding largely on small birds or mammals or large insects. In the African tropics there are additional species of "typical" shrikes of essentially similar form and habit, but there are a good number of brilliantly colored species known as "bush shrikes," with red, yellow, green, and blue markings in varying combinations. These bush shrikes leave on the observer the same impression that do tanagers in the Americas, and while there are no definite species of the two groups that closely approximate each other in pattern, the impression does not become diminished because of this lack of specific instances of convergence. The two groups make quite similar nests; their general actions are quite reminiscent of each other, although their diets are not wholly similar, the tanagers being more addicted to fruits and less to insects than the bush shrikes. But, as shrikes go, the bush shrikes are less strictly carnivorous than their northern relatives; they do eat some fruits and vegetable matter and, where carnivorous, they are restricted to insects, apparently never attacking smaller birds or mice. On the other hand, the tanagers, although frugivorous, also consume quantities of insects. Such species of bush shrikes as comprise the genus *Chlorophoneus,* for example, are quite clearly ecological and visual counterparts of such tanagers as *Thraupis* and *Piranga*.

The role of leaf-gleaning insect feeders played in the New World by the vireos (*Vireonidae*) is filled in the tropics of the Old World by the superficially very similar white-eyes (*Zosteropidae*). The birds of the two families are alike in general size, form, and dull-green coloration (with a few exceptions) and in their actions as well. In field notes made in South Africa in 1924 I noted of one of the white-eyes, *Zosterops virens,* that

> . . . . at Woodbush, Transvaal, this species was breeding commonly, and I found nine nests. The nests are similar in appearance to those of the red-eyed vireo (*Vireosylva olivacea*) of North America, but have the horizontal supporting twigs, from which the nests are hung in a semipensile fashion, slightly below the rims of the nests. . . .

In some species, then, even the nests are similar, and the parallelism between the two groups is marked indeed.

In tropical America there is a large and quite diversified family of what are essentially tree-climbing birds, called the woodhewers (*Dendrocolaptidae*). These birds, with rather stiff woodpecker-like tails that serve as props as they climb about on the tree trunks, are frequently streaked in coloration—browns of various degrees of depth, with some blackish, buffy, and pale tawny. They are bark gleaners in their feeding habits, probing with their highly specialized and diversified, variably shaped bills into crevices of the bark or even pecking at the wood for their insect food. A striking parallel to them in North America and Europe is afforded by a genus of a quite unrelated family, the creepers (*Certhiidae*). Our common brown creeper, *Certhia familiaris,* is so similar, in an admittedly superficial way, to some of the smaller woodhewers that if a specimen of it were placed in a tray of the latter group it would take the eye of an experienced ornithologist to pick it out.

The babbling thrushes, or babblers (*Timaliidae*), of the Old World contain numerous forms (such as the genera *Crateropus* and *Turdoides*) which take the place ecologically of the thrashers and mockingbirds (*Mimidae*) of the New World. In fact, so close is the general agreement that if one of our thrashers were to be taken, let us say, as an escaped cage bird in Asia or Africa, it

would undoubtedly be assumed to be a babbler. (At the risk of spoiling this case from the standpoint of the present paper, it may be asked if the *Mimidae* really are a family separable from the *Timaliidae.*)

In the Americas the role of nectar- and nectar-insect feeders is filled by the large and highly specialized family of hummingbirds (*Trochilidae*). In the tropics of the Old World the same niche, or series of niches, is filled by the quite unrelated, but often similarly brilliantly colored and small-sized sunbirds (*Nectariniidae*). Both groups comprise many species and are quite divergent within themselves in minor details. In the American tropics the honey-creepers (*Coerebidae*) also help to fill this niche. The general resemblance between many of the sunbirds and the hummingbirds is close enough to baffle the nonornithological taxonomist, which is merely another way of saying that it is very considerable. The specialist can easily distinguish them, and his particularized knowledge may tend to make him less appreciative of the similarity between the two groups, as he no longer sees them with ordinary eyes.

THE number of like instances may be extended to the point where it grows wearisome, and we may merely mention, again only as samples, two cases of much less perfect parallelism which are, nevertheless, in the same general category as those already briefly described.

In the forests of the American tropics are numerous forms of brightly colored jays (*Corvidae*), whereas in the similar sections of Africa we find none of these birds, although other members of the same family—the "true" crows and ravens—occur in the open savanna districts. In the African forests the jays are replaced ecologically by a wholly unrelated group of birds, the turacos (*Musophagidae*), a family related to the cuckoos. The forest-dwelling species of turacos are of about the same size (with one exception) as the jays, are of bright, though very different, coloration, make fairly similar nests, and have similar feeding habits. In the open savanna country of Africa are to be found some plain-colored species of turacos, which, in a very loose way, may be said to take the place of the rather drab jays of the genus *Psilorhinus* of similar habitats in tropical America.

The fowl-like birds (*Phasianidae*) of the Old World are largely replaced ecologically in tropical America by the tinamous (*Tinamidae*), a more "primitive" group which has come to occupy the place taken in Africa by the francolins and spur-fowl (genera *Francolinus* and *Pternistes*). The parallelism here is far from perfect, and while the birds of the two groups do fill the same ecological niches there is little similarity between their plumage patterns.

The number of possible permutations and combinations of the different colors and patterns (spots, bars, stripes, etc.) found in birds is far greater than the number of kinds of birds. It is therefore interesting, and probably significant, that there should be as many instances of convergence among unrelated groups as there are. It is all the more intriguing when we find that these similarities in appearance are so often correlated with equally marked similarities in habit.

SCIENCE ON THE MARCH

THE CURRENT SUNSPOT TREND

THE year 1946 has seen the largest number of sunspots that have appeared in the present cycle, which started from a minimum in the early part of 1944. In the first week of February of this year the largest sunspot ever to be observed in sunspot history was in appearance and was accompanied by magnetic disturbances, blackouts in radio communication, and brilliant displays of the northern lights. The important relation between sunspots and radio communication conditions has given rise to a new interest in the prediction of the sunspot curve. So intimately related are the optimum usable frequencies for world-wide radio transmission to the number of spots appearing on the sun that if we know the behavior pattern of one of these variables we can, with reasonable assurance, deduce the other.

Long-distance radio communication depends upon the ability of the ionized regions of the upper atmosphere to turn back the transmitted sky wave earthwards, thus making reception over long paths possible. The reflection of radio waves is an electromagnetic phenomenon which depends upon the ionic concentration, or the electron density, at the reflecting layers. This ionization seems beyond much doubt to be due to radiation at the extreme ultraviolet end of the solar spectrum, an emission which increases rapidly with the increasing number of sunspots. By sending radio pulses directly upward and catching the return wave on the oscilloscope, one can determine the height of this reflective ceiling by measuring the number of microseconds that have elapsed between the record of the outgoing and the returning pulse. Furthermore, by constantly raising the frequency during this operation, a frequency may be found at which the wave penetrates the reflecting layer and fails to return. This is commonly known as the *critical frequency* and is a measure of the electron density existing at the time the observation is made. The accompanying graph (Fig. 1) shows how remarkably the electron density at the E layer, often termed the Kennelly-Heaviside layer, varies with the number of sunspots. The upper curve is the result of plotting the running means, or moving averages, of the sunspot numbers, taking twelve months at a time from 1934 to 1946. The lower curve represents the number of electrons per cubic centimeter at E-layer levels 70 miles above the earth's surface, as calculated from observed critical frequencies over Washington. It is from this layer that waves of medium frequency such as are used in commercial broadcasting are reflected back to earth. An examination of this curve will show that whereas there were the equivalent of 160,000 electrons per cubic centimeter in the atmosphere at the E layer during sunspot maximum in 1937, there were but 111,000 electrons per cubic centimeter at sunspot minimum in 1944. The change in ionization between sunspot minimum and sunspot maximum is approximately 45 percent. To predict ionization conditions during the next year or two, one must anticipate the future of the sunspot curve.

It is a bit surprising that although sunspots have been observed for over 300 years we do not yet know what makes them. It is common knowledge that sunspots are due to atmospheric disturbances in the surface layers of the sun. Whether or not the cause of these disturbances is deep-seated and is to be found within the sun itself or whether there are some ex-

terior factors of a more or less periodic nature responsible for the occurrences of sunspots is still a debatable question. If we knew the ultimate cause of these solar disturbances, it would probably help very much in solving the mystery of the solar cycle and predicting the future behavior of the sun. Some astronomers beg the question and assume that its future is unpredictable.

Various methods have been employed by many workers in an endeavor to improve sunspot predictions. In view of our lack of knowledge, only some empirical method based on the general pattern of recurrences can be used in making estimates of the future of the sunspot curve. Mathematicians have spent many hours in applying harmonic analysis, utilizing all the data available from the beginning of sunspot observations in 1750. However well such an analysis may reproduce past performance, almost invariably it fails in predicting the future. Any systematic study of the records of sunspots will reveal that while the time between maxima and minima has averaged about 11 years, the interval has actually varied all the way from 9 to 17 years. The chance that a given sunspot maximum may be predicted by adding 11 years to the previous maximum is only about one in four. However, there does seem to be some general pattern that the sunspot curve will follow when it is once started on a given

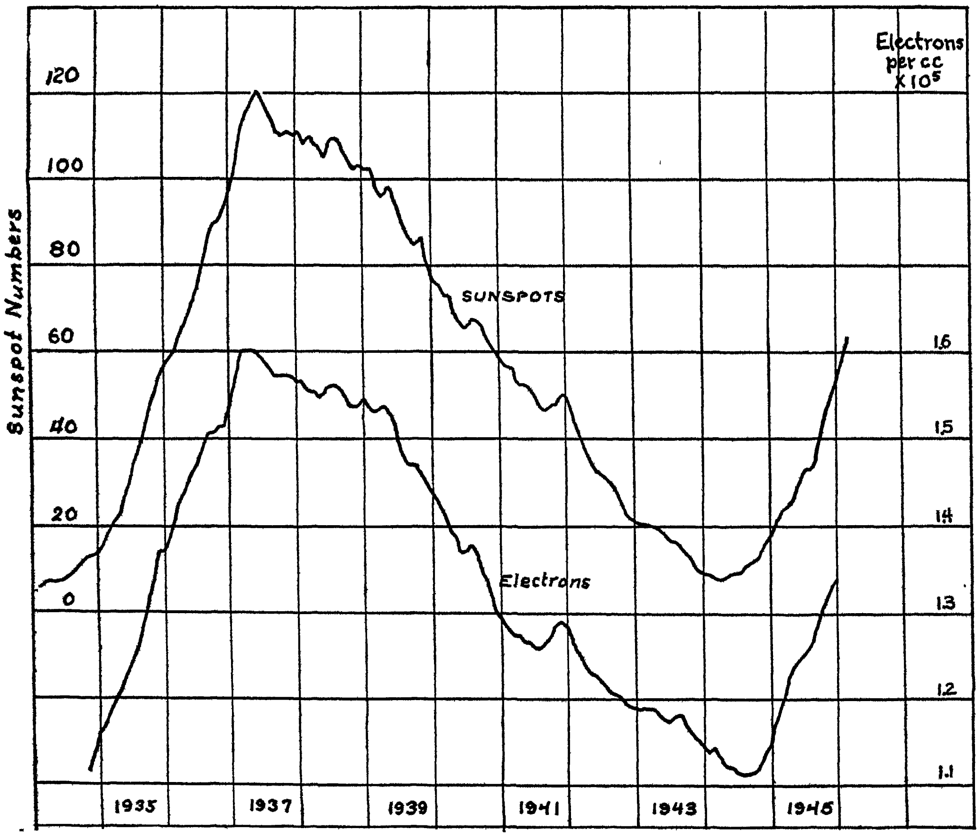

FIG. 1. ELECTRON DENSITY AT THE E LAYER AND NUMBER OF SUNSPOTS
THE ELECTRON DENSITY IS BASED ON AVERAGES BETWEEN 9:00 A.M. AND 3:00 P.M.

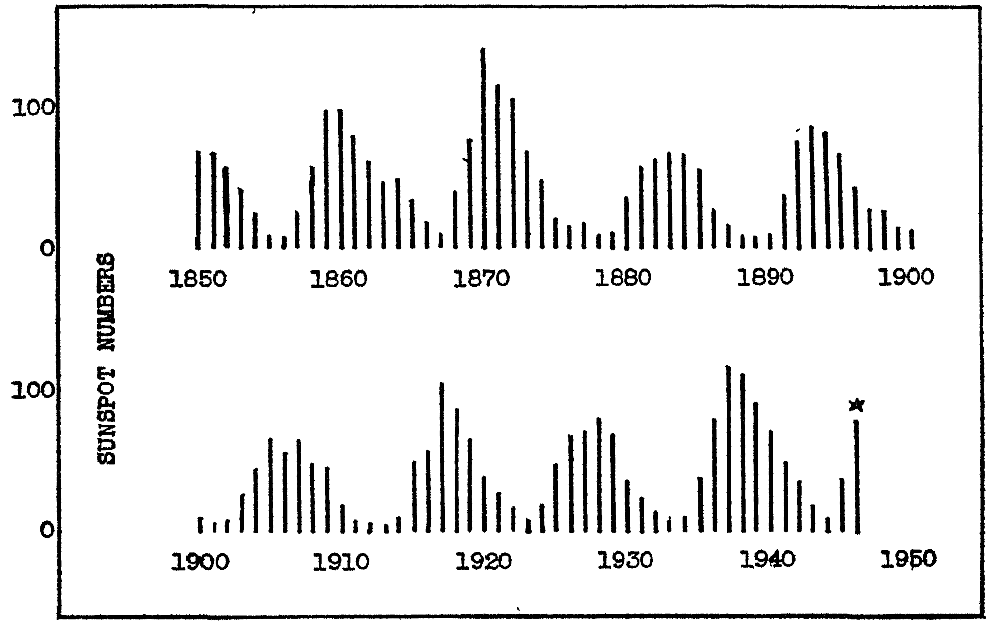

FIG. 2. SUNSPOT CYCLES, 1850–1946
THE NUMBER OF SUNSPOTS FOR EACH YEAR IS SHOWN; THAT FOR 1946* IS A 7-MONTH AVERAGE.

cycle. Dr. John Q. Stewart, of Princeton University, and his associates have recently devised a method for predicting the time of sunspot maximum, treating each rise and fall as an individual event without making any assumption as to long-term periodicities. Studying a number of these individual outbursts, Dr. Stewart has devised a formula for predicting the remaining course of a given sunspot cycle with relatively good success. He has communicated to me his prediction of the next maximum as 1948.0. Dr. C. N. Anderson, of the Bell Telephone Laboratories, in a paper recently published, ventures 1951 as the year of the next maximum. More recently, Waldmeier, in the *Journal of Terrestrial Magnetism,* has predicted a maximum as early as 1947.6. The methods used at the Cosmic Terrestrial Research Laboratory at Needham, taking into consideration the mean latitudes of the spots in both hemispheres and the drift toward the solar equator in the course of a cycle, have led to a prediction of 1948.2.

It should be pointed out that since the discovery of the change in the polarity of the magnetic fields of sunspots in 1912 by Dr. George E. Hale and his associates, at the Mount Wilson Observatory, there is good reason for believing that the full sunspot cycle is of about 22 years' rather than 11 years' duration. A study of the past 70 years of sunspot cycles (Fig. 2) shows also the definite tendency for a change in pattern of the sunspot curve in alternate maxima. The sunspot maxima of 1870, 1893, 1917, and 1937 were all characterized by a sharp peak following a rapid rise. The maxima of 1883, 1907, 1928, on the contrary, show a rounded top with high sunspot numbers lingering for a year or two around maximum. If this is a present trend, then we should anticipate that the coming maximum may yield relatively high sunspot numbers throughout both the years 1947 and 1948, with the top of the

hump occurring in the early part of 1948. However, the sun appears to be full of surprises, and we shall know better whether this trend is to persist in the future after the next maximum is past.

There are, of course, wide fluctuations in the daily and monthly values, largely owing to the 27-day rotation period of the sun on its axis, bringing into view a given group of disturbances that may persist sometimes for weeks or months. For studying the long-term trend a 12- or 13-month moving average eliminates most of these day-by-day and month-by-month irregularities. However, for a study of correspondence with geomagnetic phenomena and especially radio communication conditions, shorter periods are of interest. In this case, quarterly averages or, better yet, 3-months' running means form a satisfactory curve for the study of secondary fluctuations of solar activity. From a recent study of such secondary fluctuations it would appear that we may expect another abrupt rise of solar outbursts in the latter part of 1946 or early 1947 while the main trend is still on the rise. An interval of from 12 to 15 months characterizes the space between these minor peaks, and this interval may in a large measure govern the success of any prediction for the actual maximum of the coming cycle, especially so far as fractions of a year in predicting are concerned.

The effect of sunspots upon the earth has long been an intriguing question. The oldest terrestrial concurrent phenomena have been those of the changes in the earth's magnetic field. These have been known to follow sunspots for over a century.

It was the advent of radio and the discovery of the ionized shell of the earth's atmosphere that made possible the explanation of the changes in geomagnetic phenomena with changes on the sun. When flares of ultraviolet light, or corpuscles, emitted from sunspot areas disturb the electron density in the upper air, there is a resultant electrical current aloft which induces a magnetic field on the earth that produces the well-known magnetic storms and compass variations accompanying sunspot phenomena. It is thus seen that the effect of sunspots on the earth is a direct one and that whatever other terrestrial effects may or may not be caused, electrical changes accompanying sunspots have been definitely traced in our atmosphere to within 70 miles of the earth's surface. The growth of trees in selected regions of the globe has also been found to show a fairly close correspondence with the sunspot cycle, presumably because of climactic changes, of which precipitation appears to be most important. There is also accumulating evidence that changes in solar radiation may have an effect upon short-time weather changes, but the problem is a complex one. Whether or not other terrestrial phenomena more or less periodical in character may be related to sunspots remains yet to be proved, and such questions must be regarded for the time being as lying in the field of speculation.

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BOOK REVIEWS

EARLY THEORIES OF MAGNETISM

Soul of Lodestone, The Background of Magnetical Science. Alfred Still. x + 233 pp. $2.50. Murray Hill Books, Inc. 1946.

THE author of this book is an electrical engineer long distinguished as a practitioner and as a teacher of his profession. Arrived at "the Indian summer of his days," he holds that "while the light endures it is good to look around and examine all things. . . . There is a primitive urge that bids us seek." He has looked back across the centuries and has reviewed all that men have thought and written and done about electricity and magnetism. And the world is richer by two books, *Soul of Amber* and *Soul of Lodestone.*

In these books the reader joins his master and guide for a journey through the ages. They walk and talk with the philosophers, live their lives, and share their thoughts. They look upon amber and lodestone as the philosophers saw them. And how rational the old views were, and how useful in their times! The reader grows as he journeys. He learns through the years to be ever critical of his thoughts.

Quotations from the books may suggest their flavor:

> The lodestone draws iron from a distance and has a secret understanding with the poles of the world. *Lodestone,* p. 192.

> A great deal has been published in many languages on the earlier theories of electricity. . . . If we consider these theories critically and without prejudice, they will begin to appear not unreasonable in view of the evidence upon which they were founded. *Amber,* p. 141.

> The latest theory is often the most pleasing and, as such, is helpful for the time being in stimulating the scientist to further efforts. But there is no finality. *Lodestone,* p. 200.

> What a good man bequeaths us of himself—of what he was apart from what he accomplished—may be of even greater value than his contributions to our knowledge of the physical world. (Michael Faraday). *Amber,* p. 241.

Soul of Lodestone guides its reader until the electron and the quantum appear and the atom discloses a structure. Then it guides no more. But the soul of lodestone marches on. Let the reader turn to *Science,* July 26, 1946, and consider Professor Barnett's account of the International Conference on Magnetism held at Strasbourg during May 1939. He may glean from it that philosophers are still abroad in many lands; and he may be led to read the address that closed the conference, "Magnetism in the Last Fifty Years," by E. Bauer.

As Professor Still taught it, electrical engineering must have been a cultural subject in the richest and fullest meanings of the phrase.

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YESTERDAY ALONG THE HOUSATONIC

The Housatonic: Puritan River. Chard Powers Smith. x + 532 pp. Illus. $3.00. Rinehart & Company, Inc. New York. 1946.

THIS book opens with a double-page map which is irresistible to the many devoted friends of the Housatonic Valley. The valley is about 115 miles long, but the meanderings of the river give it an entire length of about 165 miles between its beginning, northeast of Pittsfield, Mass., and its final flow into Long Island Sound near Bridgeport, Conn. The whole valley and mountain-shed area is dotted with names of places in which and from which important American historical characters originated, worked, and went out to the larger world. And the region still has no end of industries that are the present-day representatives of long lines of industries marking the stages of industrial evolution. In each area where there are no industries today, there are suggestive remnants: an iron

furnace, a charcoal pit, a granite or marble quarry. There are old apple orchards with native second-growth forest trees. Among them one may find cellars and tumbled wastes of once-fine residences, formerly occupied by large and industrious families, who no longer have living representatives in the mountains or valley. If one needs modern illustrations of the valley's industrial evolution, let him note the many fallen tobacco barns, vacated when the labor situation began to choke tobacco farming; or attempt to purchase maple sugar or sirup in regions now producing just enough to remind us of what used to be; or note the splendid dairy herds and poultry flocks from which much food is shipped to large city markets; or, even more significant, observe the extensive occupancy of both farm and wooded lands by more or less wealthy city people, few of whom are descendants of early natives. And the wealth and desire for ease of these "city slickers" has changed the whole economic setup and much of the social life once so characteristic of the industrial and rural civilization of the valley.

The river, which the Indians called Hous-aton′-uck ("Place-beyond-the-mountains," meaning Berkshires), also had other names for one or another part of its course. But the author coins the name "Puritan River," which name he proceeds to justify. First, he recounts the doings of several Indian tribes who claimed ownership of different parts of the entire area; an account of extreme interest. He characterizes these tribes as "Heathen of the Land." This prepares the way for accounts of subsequent numerous efforts of so-called religious groups who sought their own freedom while planning new settlements at points throughout the entire Housatonic area.

There follow chapters devoted to different regions of settlement: Stratford, Danbury, New Milford, Stockbridge, and Pittsfield, with references included to almost all towns and community centers of the entire area. The book includes dates and locations of first settlements, the people concerned, usually with their descendants down to modern times, and stories of the agricultural and other productive interests.

From early history the Housatonic area has been educationally inclined. Perhaps life was hard enough to emphasize the need of education. Anyway, fee schools flourished and drew support from outside as well as from the valley. In due time those schools declined, and public schools, caring for everybody's children, developed. Private college-preparatory and "finishing" schools then came and still feature the whole valley. Eminent scholars, scientists, professional men, and businessmen even made their homes in Pittsfield, Great Barrington, Canaan, and elsewhere. Great Barrington, Stockbridge, Lenox, and Pittsfield became desired summer regions for persons of great wealth. They paid fabulous prices for large areas, built absurdly large and ornate castles (cottages), imported foreign superintendents, gardeners, servants, and all that goes with them. Some of these estates have already reached the third-generation breakup. Most of the imported help has filtered into the industrial and social life of the region, even in some cases becoming owners of parts of the estates once operated by their wealthy and aristocratic employers.

The book is anecdotal, even gossipy at times, and so filled with local color that once started it is difficult to stop reading it. Its illustrations may be good art, but do not illustrate so well as would good photographs. The closing chapters discussing the meaning to America of the kind of life, agriculture, industry, and society which were characteristic of upper Housatonic estates are rather fundamental to modern interpretations

of democracy. Many quotations such as the following could be made showing the trials of aristocracy amidst democracy. Speaking of the two daughters of "one of the most refined cottagers," the author says:

> Because of a faint psychopathic taint in the young ladies' inheritance, psychiatrists advised the father to confine them from social contacts until they had passed a certain age. The prescription was enforced for several years. Then, on the same day, the unfortunately healthy American girls eloped respectively with the head chauffeur and the poulterer, the four of them going over the hill to Richmond where the Congregational minister tied the unfilial knots.

The closing chapter, Baedeker in a Canoe, describes an imaginary trip the length of the river with side trips to view today's life and industries; it makes one want to travel again over the entire valley. The whole book is a highly significant one on American history.

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CHILD PSYCHOLOGY

Manual of Child Psychology. Leonard Carmichael, Ed. viii + 1068 pp. Illus. $6.00. Chapman and Hall, Ltd. London. John Wiley and Sons. New York. 1946.

ASSUREDLY not a book to be damned with faint praise, Dr. Leonard Carmichael's new *Manual of Child Psychology* will be enthusiastically received by workers in the fields of pediatrics, child guidance, psychology, psychiatry, medicine, and education.

The scope of the manual, in Dr. Carmichael's own words, is that of "an advanced-level textbook designed to bridge the gap between elementary textbooks in this field and the scientific periodical literature of psychology." The material is presented as a series of separate chapters, each written by a recognized authority: Anderson, Cruikshank, Pratt, Thompson, Gesell, McGraw, Goodenough, McCarthy, Harold E. Jones, Dennis, Mead, Vernon Jones, Jersild, Lewin, Doll, Miles, Terman, and Carmichael himself. The purpose of the manual is "to provide an accurate and coherent picture of some of the more important aspects of research in the scientific psychology of human development," and it demonstrates clearly that in child psychology "the speculative period is definitely past."

In Dr. Anderson's chapter, Methods of Child Psychology, attention is directed to changes in the concept of the nature of the child, types of problems dealt with in child psychology, central problems of method in attacking specific problems in the field, sources of material for child study, techniques for securing data, the development of measuring instruments and the determination of their precision, sampling, the organization and design of studies, variations of techniques with age, and finally the evaluation of a study. This last section of Anderson's on evaluation of studies and checking on planned researches has value not only for scientists in psychology but also for those in many other fields. To this reader, the two columns of questions used to analyze studies constitute some of the most valuable material in the compendium; if used carefully by all workers in the field, they would be instrumental in eliminating some of the journal literature of dubious merit.

In dealing with the problem, "What is the origin and what is the embryology of the behavior patterns which are significant in an understanding of human mental life?" Carmichael treats the development of behavior in the lower vertebrates (with critical appraisal of the work of Preyer, and of Coghill on *Amblystoma*); the development of behavior in the embryos of birds (citing the work of Kuo on chick embryos); the development of prenatal behavior in the infrahuman mammal; certain general aspects of human fetal development;

nonoperative studies of behavioral development in the human fetus; the study of behavior in operatively removed human fetuses; the special senses in human prenatal life; and the senses in general relationship to the onset of mental life in the prenatal period.

I mention the order in which these topics are discussed to indicate the logical presentation of material in these two chapters. The remaining seventeen chapters are presented no less effectively by their several authors.

Equipped with the material in Carmichael's chapter, the advanced student is then properly prepared to go on into the next five sections of the manual: Animal Infancy, by Cruikshank; the Neonate, by Pratt; Physical Growth, by Helen Thompson; the Ontogenesis of Infant Behavior, by Gesell; and Maturation of Behavior, by McGraw. The figures, photographs, tables, charts, and graphs in these chapters are particularly good.

Perhaps one of the most fascinating sections of the manual is that by Margaret Mead, Research on Primitive Children, which includes forty photographs of various forms of child behavior among the Iatmul, Balinese, Pilaga, Pitjentara, and other primitive peoples. Mead's field notes provide entertainment as well as instruction; her comments on the need for future research among children in the few surviving primitive societies are well taken. Mead points out that once these societies have yielded to culture contact, we shall have no possible way of replacing them.

Doll's chapter on The Feeble-Minded Child is interestingly supplemented with over forty photographs, depicting clinical types of mental deficiency, grades (degrees) of mental deficiency, institutional training of feeble-minded children, occupational training of high-grade mental defectives, and cerebral anomalies in mental deficiency. Indeed, one of the most praiseworthy features of the entire manual is the liberal use of photographs, diagrams, charts, figures, etc., throughout.

In presenting so many and so varied a collection of points of view in the special fields of research in child psychology, Dr. Carmichael has accomplished an excellent piece of work. His manual is valuable for many features, not least of which are the splendid bibliographies found at the end of each chapter and the carefully prepared index. Graduate students and specialists in related fields will appreciate these fully as much as the wealth of information in the compendium itself. The proofreading must have been a genuine labor of love, for I met with no typographical errors whatever in the manual. All those associated with Dr. Carmichael in compiling the manual deserve individual congratulations on their efforts and highly successful attainments.

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AGASSIZ THE TEACHER

Louis Agassiz as a Teacher. Lane Cooper. 90 pp. Portrait. $1.50. Comstock Publishing Co., Ithaca, N. Y. 1945.

IN THIS volume, a revision and amplification of an edition published in 1917, Professor Cooper has brought together various extracts illustrating the method of pedagogy so successfully practiced by [Jean] Louis [Rodolphe] Agassiz, the Swiss-born naturalist who distinguished himself in America lecturing and teaching zoology at Harvard College. Scarcely a man is now alive who personally remembers him, but there has grown up around his name an aura of legend, anecdote, and glory that will last, we hope, forever. (Breathes there the man who has not read that classic essay of Dallas Lore Sharp, "Turtle Eggs for

Agassiz"?) Agassiz belonged, indeed, in a great triumvirate of American naturalists—John James Audubon, the artist; Henry David Thoreau, the philosopher; and Louis Agassiz, the teacher-scientist. Any book about him is important to American science, as any book about Lincoln is to American history.

The volume leads off, following an introductory note by Professor Cooper, with a brief account of Agassiz at Neuchâtel reprinted from Mrs. Agassiz's *Louis Agassiz, His Life and Correspondence* (1885) and A Sketch of the Life and Work of Agassiz, an essay by Helen Ann Warren (Mrs. Malcolm D. Brown) that first appeared in THE SCIENTIFIC MONTHLY (1928) and was later (1934) revised for *The American Scholar*. Then comes another excerpt from Mrs. Agassiz's *Life* on Agassiz at Harvard, followed by four firsthand testimonials: How Agassiz Taught Professor Shaler, from *The Autobiography of Nathaniel Southgate Shaler* (1907); How Agassiz Taught Professor Verrill, from a private letter from A. E. Verrill to Lane Cooper; How Agassiz Taught Professor Wilder, from an article by Burt G. Wilder in the *Harvard Graduates' Magazine* (1907); and How Agassiz Taught Professor Scudder, from a paper by Samuel H. Scudder dating from 1874 in *Every Saturday*. The remaining four chapters consist of a woefully incomplete list of Agassiz's pupils, from the SCIENTIFIC MONTHLY article cited above; an essay on Agassiz's personality and on his death, by Lane Cooper; a few pages of Obiter Dicta by Agassiz himself apropos of his pedagogy; and finally two passages for comparison with the method of Agassiz, one from the *Encyklopädie und Methodologie der philologischen Wissenschaften* of August Böckh, German classical scholar and a near contemporary of Agassiz, on the study of history and literature, and one from Plato's *Symposium*.

Just what was Agassiz's philosophy of teaching? Perhaps it is best described in the words of Böckh:

> Everything in science is related; although science itself is endless, yet the whole system is pervaded with sympathies and correspondences. Let the student place himself where he will—so long as he selects something significant and worth while—and he will be compelled to broaden out from this point of departure in order to reach a complete understanding of his subject. From each and every detail one is driven to consider the whole; the only thing that matters is that one go to work in the right way, with strength, intelligence, and avidity. Let one choose several different points of departure, working through from each of them to the whole, and one will grasp the whole all the more surely, and comprehend the wealth of detail all the more fully. Accordingly, by sinking deep into the particular, one most easily avoids the danger of becoming narrow.

So it was that Agassiz would place a fish, a clam, or what not before the student and expect him, without the aid of dissecting knife or microscope, by sheer objective observation and a persevering intelligence, to drain the cup of knowledge dry so far as the specimen before him was concerned. If the method seems to us a bit cruel, we must remember that with it all went the teacher's compelling and lovable personality and his vitality. As Professor Wilder says:

> The secret of his greatest power was to be found in the sympathetic, human side of his character. Out of his broad humanity grew the genial personal influence by which he awakened the enthusiasm of his audiences for unwonted themes, inspired his students to disinterested services like his own, delighted children in the school-room, and won the cordial interest, as well as the co-operation in the higher aims of science, of all classes, whether rich or poor.

It is good to have this devoted little anthology testifying to Louis Agassiz's greatness. When he was once asked, "What do you regard as your greatest work?" he replied, "I have taught men to observe." Perhaps even twentieth-century pedagogues, who seem at the moment to be needing a few ideas where-

with to meet the challenge of the New Age in education, might still take a tip from Louis Agassiz's fish. His methods, to be sure, were not new with him, but he made them work, and students came away from his instruction inspired and equipped to meet the world. And—

Forever seeking truth, not vain acclaims,
He kindled, on the way, a thousand other flames.

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GODDARD'S ROCKETS

Rockets. Robert H. Goddard. xix + 79 pp. $3.50. American Rocket Society. New York. 1946.

THIS book is a reprint of Dr. Goddard's famous reports to the Smithsonian Institution. The originals are out of print. The foreword to this edition was written by Dr. Goddard on May 1, 1945, shortly before his death on Aug. 10, 1945.

It is generally recognized that Goddard laid the foundation of modern jet and rocket propulsion in his two articles published in the *Smithsonian Miscellaneous Collection* and reproduced by facsimile printing for the American Rocket Society. The first article, "A Method of Reaching Extreme Altitudes," appeared in 1919 (69 pp., 10 plates). There is given in detail work performed at Clark University on powder rockets. The fundamental engineering data on nozzle design, jet velocity, propulsion *in vacuo*, etc., are developed to the experimental stage. Calculations and experimental data are included on the size of a flash powder charge on the moon visible from the earth. A very important series of data prove that rockets should take off at a high altitude for maximum performance. This point has not been adequately utilized by our rocket proving fields today. The effect of air pressure is astounding. For example, at 15,000 feet altitude only about half the fuel charge is required to reach the same height as from a start at sea level. The importance of high-velocity gas streams is described. The efficiencies of various rockets are reported from experimental tests. Work on the use and recovery of testing apparatus to be installed in a rocket is included. The mass of scientific and engineering data included in the article is well worth the price of the book to a rocket investigator.

The second article, "Liquid-Propellant Rocket Development," was published in 1936 (10 pp., 11 plates). This was a preliminary report to the Guggenheim Foundation, which had supported Goddard's rocket research at Roswell, N. M. The data on liquid-fueled rockets in this report have been verified in a rather dramatic fashion by the Nazi V–2 and Me–163 high-altitude rockets and rocket planes in the recent war. It is interesting to note the discussion of the gyroscopic stabilizers by Goddard in the light of their development today for the same purpose.

The plates for both articles are a part of the archives of rocket development and date the work very effectively.

G. Edward Pendray, Secretary and one of the directors of the American Rocket Society, wrote a biographical appreciation of Dr. Goddard for the book.

The make-up of the book was well conceived, and it should be on every rocket experimenter and enthusiast's bookshelf.

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COMMENTS AND CRITICISMS

The Criteria of Patentability

The timely article "Criteria of Patentability" by Major J. H. Byers appearing in THE SCIENTIFIC MONTHLY, May 1946, contains the following very appropriate statement: "There really ought to be attached to each and every patent that issues from the Patent Office the following warning: 'Inventor beware! This patent is only a license to sue. . . . What the Court will do to it is beyond prediction.' "

The importance of Major Byers' statement will, no doubt, be more fully realized if a few additional remarks on patent litigation are made, showing for instance how very true Judge Learned Hand's testimony before the Committee on Patents, House of Representatives, in 1919 was when he made the statement that "some of them [Judges] have a constitutional inability to understand complicated questions of machinery, and we all have a very great inability to understand the more difficult questions such as come up in electrical and chemical patents. I think I can safely say that all of us, when we get a really stiff patent, involving electrical current and questions of chemistry, are helpless" (P. 150. Hearings before the Committee on Patents, U. S. Senate, Seventy-fifth Congress).

Questions regarding sufficiency of disclosure, prior disclosure, sufficiency of claims, and infringement primarily involve technical questions. How then can Federal Judges who are admittedly helpless in such matters be relied upon to properly adjudicate a patent, and why does Congress permit such a condition to exist? It is true that the late Senator McAdoo in 1937 introduced a bill regarding a Court of Patent Appeals providing scientific advisers, and hearings were held, but nothing came of it.

I illustrated these undesirable conditions in great detail to the Temporary National Economic Committee in 1939, as the result of an infringement case in which I testified in 1937 before the U. S. District Court, Southern District of New York.

The patent in question, a basic Method Patent on Mercury Arc Rectifiers, based on acknowledged original research, was willfully infringed by a corporation. Basic claims were allowed by the Examiners-in-Chief of the U. S. Patent Office, and equivalent patents were granted by the Patent Offices in five predominant countries. I testified and proved that the method discovered in 1912 was not only overlooked by such inventors as Cooper Hewitt and his co-workers, Steinmetz and his co-workers, and all other authorities, domestic and foreign, but it was not until 1926 that the manufacturers were aware that this basic principle, now universally used, is essential for most efficient operation of large capacity Mercury Arc Rectifiers. So thorough was the testimony that the defense was unable to bring out a single publication, domestic or foreign, showing anticipation, although defendant's counsel, by distorting the quotations from patents and publications of the prior art and giving to them a meaning not intended or contemplated by the authors, endeavored to create the inference that there was knowledge of plaintiff's discovery prior to his disclosure.

However, defendant's patent attorney and "expert" succeeded in deceiving the Court by distorting the content of an article which, incidentally, had been carefully considered by the Examiners-in-Chief. Defendant's expert testified falsely in regard to the content of mentioned article after I had fully explained to the Court how defendant's patent attorney had distorted the meaning of the article.

The District Court held that there was no infringement, although the evidence conclusively showed there was infringement beyond a doubt. Since the District Court erred in twenty points, the case was brought before the Circuit Court of Appeals, Second Circuit.

Although the article in question taught just the opposite of what is disclosed in the infringed Method Patent and clearly brought out at the trial and in our briefs, yet the Circuit Court of Appeals erroneously claimed it to be an anticipation and thereby saved itself the trouble of considering the infringement question.

Counsel for plaintiff, after studying the situation, came to the following conclusion:

> The U. S. Supreme Court would have jurisdiction of the case, but applications for certeriorari are not freely granted and must be based on certain particular grounds, especially on questions of Law. Whether the Court would regard the case as depending on a question of Law would be doubtful, as all procedural matters were properly handled in the Patent Office as well as in the Courts. The question of novelty or prior disclosure would probably be regarded as a question of fact, or science, which the Supreme Court might not deem itself called upon to review.
>
> However, as to the validity of the Method Patent, there is no dispute as to the facts, no question of conflict in the evidence, so that the answer depends upon the interpretation of the facts. This could be regarded as a question of Law. How the Supreme Court would regard it cannot be foretold.

This revealed an amazing situation. Although the decisions by both Courts were contrary to what the statement of evidence very clearly revealed and, therefore, erred, yet there apparently existed no good reason for approaching the U. S. Supreme Court; although constitutional rights were transgressed to the nth degree, yet "the Supreme Court might not deem itself called upon to review."—WILLIAM TSCHUDY.

Principles and Problems of Public Medical Care

It is always the privilege and critical right of the reviewer to disagree with the point of view and basic philosophy of both book and author. However, when the reviewer of a serious book rejects both the point of view and the philosophy expressed and states dogmatically, "Its basic philosophy will not appeal to scientists," and bases his own rejection on anything but scientific grounds, it warrants a protest.

We have reference to Edward J. Stieglitz' review of Franz Goldmann's book *Public Medical Care* in the May issue. Stieglitz' emotional approach to the problem of public medical care is too palpably evident—to say nothing of his unscientific and loose usages of terminology in discussing problems raised in the book. He states: "The book is written from the point of view of a social worker primarily concerned with institutions, not from the viewpoint of the physician concerned with individuals." Why Dr. Goldmann's association with the Yale School of Medicine as Associate Professor of Public Health should disqualify him from having the physician's point of view is hard to understand.

The reviewer may disagree with Dr. Goldmann's medical-sociological point of view, but let us be spared the loose thinking, the repetition of clichés which are vague in content and meaningless on analysis. After the above-cited quotation the reviewer continues, "It is notably lacking in appreciation of the truly American tradition of individual initiative." Let us take a closer look at this thing called "individual initiative" (which appears to be another variation of "rugged individualism"). While this tradition had its roots in the historic and economic development of our country, today this concept is no longer valid. Today there are no new land frontiers to flee to, and the importance of the entrepreneur has all but disappeared in this period of monopoly capitalism. As a social concept today this idea is anachronistic in our complex society, with its enormous social interdependence for sheer survival, not only of the individual but of whole nations. To lend oneself to the perpetuation of such an outmoded social concept doesn't appear to indicate a high degree of scientific awareness of the changing social scene.

The reviewer further states there are many advocates of the idea, in addition to Dr. Goldmann, "that medical care is a government function." Does the reviewer mean those who are interested in government sponsorship of a national health program? It appears so; then he proceeds to break them down into three general groups. This breakdown is a narrow, prejudiced, and unscientific piece of analysis.

In group (1) the reviewer apparently includes the thousands of physicians in the country who are aware that the problem of health is the problem of the entire nation and not merely that of the individual who can afford to pay for medical care. He lumps in the same category the millions of trade unionists and their families, the white-collar and professional workers who have indicated their interest in proposed federal health legislation to protect themselves against economically calamitous illness by their representatives appearing at congressional hearings on such legislation during the past 8 years.

The legislators come in for their unscientific mauling in group (2). Nothing like dubbing them "politicians," with the word's connotation for venality, for setting the scene. It is ironic that the reviewer will single out for attack those few elected representatives who assume their political duties with integrity; and worse, in order to belabor his point, indulges in deliberate distortion when he says these "politicians" offer "something for nothing." This appears to be a veiled reference to National Health Bill S. 1606, sponsored by Senators Wagner and Murray and Representative Dingell, which is under fire from those in the medical profession who would in vain attempt to impede social progress. Proposals for financing this plan for national health insurance include *prepayments* by all employed, deductible from pay rolls, with a like percentage contributed by the employer. Provisions are also proposed for prepayment by individually employed, etc. Prepayments are to be made, that is, by those who will eventually benefit from the provisions of the bill; this is not "something for nothing," as the reviewer would have those believe who are unfamiliar with the pending legislation for a government-sponsored national health program.

Group (3) are the "idealistic dreamers." Is this a *precise* definition to describe those who believe democracy can be made to function? A very descriptive label to tack on those who believe that a government such as ours, which imposes enormous responsibilities on the individual and exists to carry out the mandates of its people through their legally elected representa-

tives, would not cease to fulfill this function if it assumed the responsibility for the general well-being of its people through the sponsorship of national, prepaid, health insurance measures. "Idealistic dreamers" in the opinion of the reviewer are all those who believe and support the postulate in Sec. 8, Art. 1 of the Constitution of the United States. The responsibility for the good functioning of the government devolves on every individual in our society. The good functioning of any government-sponsored national health program would involve the utmost cooperation of every individual with the doctors and the cooperative efforts of all to maintain the highest standards of health in the community.

Reviewer tosses in for good measure the tag "socialistic medicine." The die-hard opponents of National Health Bill S. 1606 (still in committee) have used this label cunningly and with deliberate design to confuse. What does this tag really mean? *What is* "socialistic medicine"? Is it pooling the resources of all medical science in the interests of the entire population? A broad concerted effort to extend the benefits of medical science to the whole of society? And if *this* is meant by "socialistic medicine," what is wrong with the idea? And if not, just *what* did the reviewer have in mind? Obviously, the word "socialistic" was intended to evoke distaste and antagonism. This word is bandied around so loosely, so inaccurately applied to any seemingly progressive measure, that the common connotation and interpretation are a far cry from the real meaning of the word. We feel it safe to make the general observation that to the majority of the people in the U. S. the word has a sinister meaning, and today, if you would discredit *any social idea* and confuse the issue, merely apply the word "socialistic" and the task is done.

Reviewer quotes from Dr. Goldmann's book, "Adequate medical care is a fundamental human right," and questions the value of the premise on the grounds of dogmatism; he then confounds the issue by offering a dogmatic statement of his own: "Health is a privilege and not a right." This is questionable logic and certainly questionable social thinking. Ethically and legally, it is accepted that "life, liberty, and the pursuit of happiness are the natural and inalienable *rights* of man." The dictionary defines "privilege" as "always special, exceptional and artificial. . . . something peculiar to one or some as distinguished from others." Reviewer fails to make clear who grants this privilege and indulges in rather cloudy thinking on the *right*-versus-*privilege* concept of the safeguarding of public health. (Just *what* does "sensible care" really mean?) Obviously, no plan so broad in scope as the proposed national health insurance plan can optimally function without the cooperation of every adult in society, based on individual responsibility. However, it cannot be deduced that such cooperation will not be forthcoming merely because such a health program is government-sponsored. The health and well-being of society is the responsibility of society individually and collectively. Our democratic government is charged in our Constitution with the fundamental duty to provide for the "general welfare." The reviewer apparently questions whether public health comes under the heading of general welfare. Without healthy bodies there can be no talk of well-being, no basis for education, for social progress and development.

The reviewer's approach to analysis of books in the field of medical sociology is anything but a scientific, rational one. Such a review as his has no place in a publication with the aims of THE SCIENTIFIC MONTHLY. There is too much confusion spread by the loose and casual usage of the English language, by the emotional consideration of vital social problems, in the daily press and periodicals of general interest. If the safeguarding of our civil liberties requires eternal vigilance, surely this same type of vigilance should be exercised in the field of science to nurture and develop the scientific point of view in the consideration of social problems.—GERTRUDE HUTCHINSON.

Our Everyday Reckonings

Mr. George Colles attempts to make a strong case against adoption of the metric system, but he has failed to move me, at least. In the first place, he does not even claim that our present system is superior to the metric system. Furthermore, he does not consider the changes that have occurred in the world during all the years since Secretary Adams first advocated the metric system. During that period physical integration has vastly outdistanced social integration. There is now a distinct division between the English-speaking nations, which do not use the metric system, and the non-English-speaking nations, which do. If we can use compulsory adoption of the metric system as a lever to induce non-English-speaking countries to adopt English (the principal language of business and science) as a secondary language, taught in all schools, a great step toward reducing this appalling lack of social integration will have been accomplished. It is interesting to note that the United States was the first country to adopt the decimal system of coinage (in the time of Adams) and that since then every country in the world has adopted it (except Great Britain, naturally).—EDWIN DURST.

THE BROWNSTONE TOWER

As predicted in the October issue, we have moved from the Brownstone Tower to our new quarters on Scott Circle at 1515 Massachusetts Avenue, Washington 5, D. C. But because we are celebrating in this issue the centennial of the founding of the Smithsonian Institution, the Brownstone Tower is not absent from it. We have placed on the cover a photograph of the Smithsonian in which the Tower and our late, beloved office behind the clock face are conspicuous. The Owl Tower is partly hidden by the tree on the right. We do not know the date of this picture, but, judging from the appearance of the cars parked at the right, we believe it must have been taken around 1930 before the Mall was made a thoroughfare and parking lot. The statue of Joseph Henry, first Secretary of the Smithsonian, now stands before the main entrance of the building as shown on page 371, and the landscaping and roads in front of the building have been greatly changed. But the building itself looks as it did during the Civil War.

We have not attempted in this issue to give a comprehensive account of "The First Hundred Years of the Smithsonian Institution." That has been done by Webster P. True, Chief of the Editorial Division of the Institution, in a beautifully illustrated booklet of 64 pages bearing the title just quoted. We offer merely a miscellaneous collection of papers by eleven members of the Smithsonian staff representing six Divisions of the United States National Museum, the Freer Gallery of Art, the National Zoological Park, the Astrophysical Observatory and its Division of Radiation and Organisms, and the Editorial Division of the Institution. Although our coverage of the activities of the Smithsonian is by no means complete, we have tried by selection of subjects in the manuscripts solicited to impress upon our readers the wide range of interests of the Smithsonian.

Only one principal article, that by Bart J. Bok, Harvard College Observatory, did not originate in the Smithsonian. His article on "Science in UNESCO" is included because it is important and timely and deals appropriately with the beginning of what may become an international extension of the aims of James Smithson.

We wish to call attention particularly to the poem on James Smithson (pp. 348 and 349) by Paul H. Oehser, Assistant Editor of the Institution. We urge those who customarily skip the poetry we publish to read "James Smithson." Here in stirring words are the aspirations of a man whose name shall never die as long as science lives.

In our hail and farewell to the Smithsonian we want to thank Dr. Alexander Wetmore, Secretary, and Mr. John E. Graf, Assistant Secretary, for their support of this issue and for their unfailing courtesies during our stay in the Brownstone Tower. To the fifth Secretary of the Institution, Dr. C. G. Abbot, our recent neighbor in the Tower, special thanks are due for providing on short notice the words of wisdom on pages 325 and 326. By personal example of unremitting and enthusiastic work in his office in the top of the Tower, Dr. Abbot demonstrates the highest devotion to the ideals of James Smithson. Our gratitude extends to all other contributors to this issue who during the heat of the summer succeeded in preparing their manuscripts for publication. To all who have helped us in the Smithsonian at other times and in other ways we say goodbye with regret. During the years to come may the Smithsonian and the A.A.A.S. continue to promote still more effectively "the increase and diffusion of knowledge among men."

F. L. CAMPBELL

THE SCIENTIFIC MONTHLY

DECEMBER 1946

METEOROLOGY GROWS UP

LT. COMDR. F. W. VAN STRATEN, USNR

OFFICE OF THE CHIEF OF NAVAL OPERATIONS, WASHINGTON

METEOROLOGY is a young science. For millennia the mariner cast his weather eye upward, forecasting a rainy day because he remembered

> If red the sun begin his race
> Be sure the rain will fall apace.

To advance to the weather forecast of 1946, in which amount and height of cloud levels, upper-air as well as surface winds, temperatures, hydrometeors, and times of incidence and cessation of precipitation are given, required the development, among other things, of a rapid method of communication. During the nineteenth century, telegraphy provided that method. Meteorology was born.

From then until the outbreak of World War II, weather science was very much an infant. Only in the twentieth century were the principles of air mass and frontal analysis evolved. In degree of fundamentality, this is comparable to the development of Dalton's Atomic Theory for the chemist or Newton's Laws of Motion for the physicist. Before the Nazi march into Poland, meteorology had advanced no farther than had chemistry in the early nineteenth century and physics in the early eighteenth.

Then came the war—modern, scientific, more deadly than any before. It was a physicist's war. Great scientific demands were made of meteorology, demands more taxing than should be put upon an embryo science. Meteorology rose to the occasion, grew, and managed to fulfill many of the obligations required of it. The influx of new blood in the form of young chemists, physicists, geologists, engineers, who through the exigencies of war were taken from their chosen occupations, put into uniform, and summarily trained in a new profession, was responsible for this growth to a large extent Fresh concepts, new knowledge, were so introduced. The civilian establishments—the Weather Bureau and certain large universities—were spurred to new efforts. The impact of electronics was another factor which rushed meteorology to its precocious maturity.

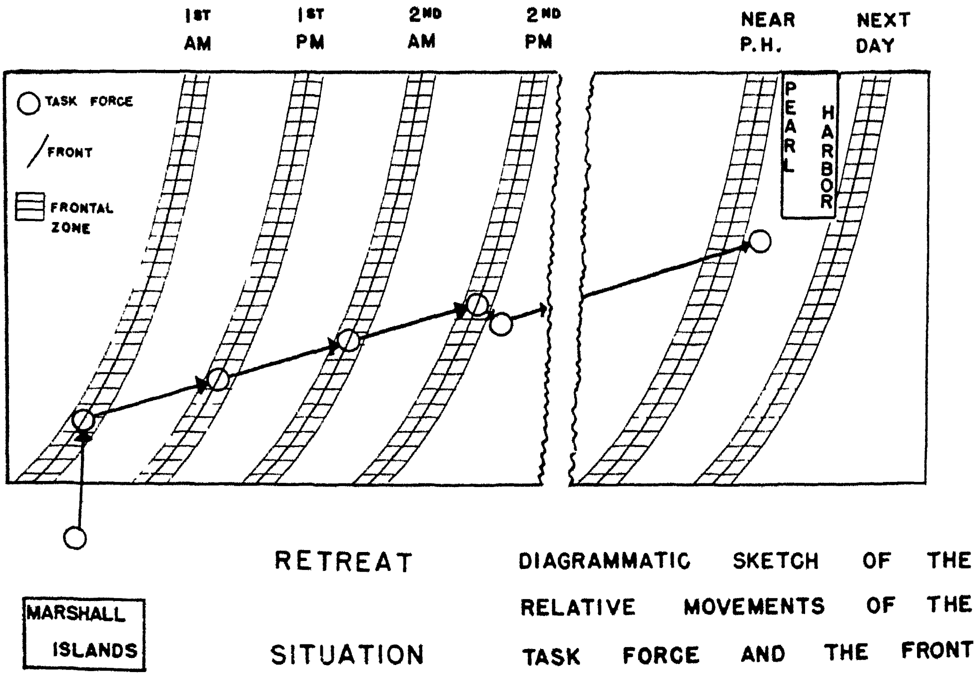
The results of this rapid development are deserving of evaluation. At close range, however, it is impossible to evaluate; one must be content with reporting. It would seem interesting, nevertheless, at this time, to record some of the progress made by meteorology during the past few years. An attempt will be made here to show some of the problems with which meteorology was faced and the techniques developed to supply the solutions to these problems. Finally, a few words will be added to emphasize the need for a complete review of this science which has grown through expediency to dimensions so vast as to be all but unsupportable by the delicate frame of its earlier development.

It should be noted that the writer is in no way compiling a comprehensive history of meteorology Her experience has been entirely with Naval Aerology—first in the Operational Analysis section and, subsequently, in the Research and Development section of the Office of the Chief of Naval Operations It is felt, however, that the problems and solutions of Naval Aerology are representative of all of meteorology. This is particularly true because of the high degree of co-operation by the Navy, Army, Weather Bureau, and universities in the prosecution of a large part of the work. Thus, only information contained in the files of the Navy will be presented here.

Navy Requirements of Aerology

Some of the demands made by the Navy of the aerological service can best be ascertained from illustrations. One such case involves the original attack on the Marshall and Gilbert islands—the raid which marked the first offensive action of our naval forces. This took place on January 31, 1942 Two task forces approached these islands, one from the north and the other from the south, subjecting Kwajalein, Maloelap, Wotje, Jaluit, Mili, and Makin atolls to simultaneous air attack. The cloudless sky and unlimited visibility permitted planes from the northern task force to attack the island installations almost continuously. However, during the early afternoon, the Japanese planes made two bombing attacks on the carrier as the last raiding planes were being landed. It was deemed advisable to discontinue offensive operations and withdraw. Considering the superior speed of planes, how would it be possible for the task force to find shelter? The aerological officer aboard the carrier had the answer.

A cold front extended southwestward from a depression centered about 150

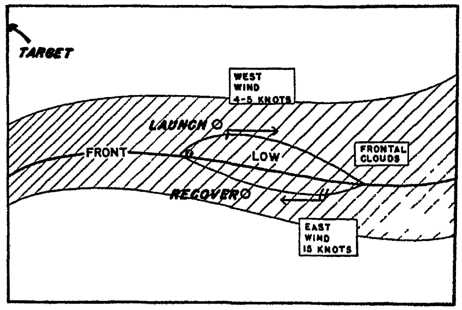


THE FIRST ATTACK ON THE MARSHALL ISLANDS

miles north of Midway. He recognized that a natural smoke screen was oriented in a direction toward Pearl Harbor. It was apparent that by steaming a northerly course at high speed until the frontal zone was reached and then changing to 065° (True), adjusting the speed to that of the front, the force would remain in the protective frontal weather all the way to its base. This tactical maneuver was executed. The front was found in its forecast position with light showers, low ceiling, and reduced visibility over a zone 30 miles wide. By radar, enemy planes were seen searching for the task force, but none was observed visually, and no counterattack materialized. Finally, on the night of February 2, the Task Force Commander decided that the ships were out of range of Japanese patrols. The task force was taken out of the front, and the helmsmen ordered to steer by remaining 30 miles off the line of continuous precipitation and towering cumulus which delineated the frontal zone. A satisfactory landfall at Pearl Harbor was made in this manner.

Another illustration may be taken from one of our attacks on Rabaul. During this discussion it is important to remember that this operation was not scheduled to coincide with favorable weather conditions Although it was an attack of necessity (to protect our landing on southwestern Bougainville), a weather situation prevailed which required an excellent appraisal of the possibilities inherent in that situation to achieve the maximum benefit from it

An analysis of the weather map indicated that the intertropical front was situated in the vicinity of the position from which the planes were to be launched. Observations made aboard ship confirmed this weather analysis but suggested as well that a wave disturbance had been formed along the front near the launching point. Reference to the accompanying figure will indicate how the wave formation assisted the task force in making a perfect strike against Rabaul. The exceedingly fine conditions for such an operation motivated the comment by the ship's company that "an angel was riding on the yardarm."



ATTACK ON RABAUL

The situation may be outlined in the following manner: The task force to the north of the disturbance was able to steam toward Rabaul, heading into the wind while the aircraft took off for their mission. The ships did not have to deviate from their base course during the launching. While the task force remained hidden from enemy scouts under the frontal clouds, the air group found the target, Rabaul, to the west of the disturbance, enjoying unlimited ceiling and visibility—bomber's weather. By the simple maneuver of steaming through the front in order to take a position south of the wave and reversing the base course 180 degrees during the withdrawal, the task force was again able to utilize the head winds in recovering the planes without the loss of any time in leaving the danger zone.

Illustration after illustration could be cited. An aerologist selected the one day out of twenty when weather conditions made possible the landing in North Africa in November 1942. Typhoons were forecast so that the United States forces could dig in and minimize the damage resulting from the big blow; also, so that an offensive group could

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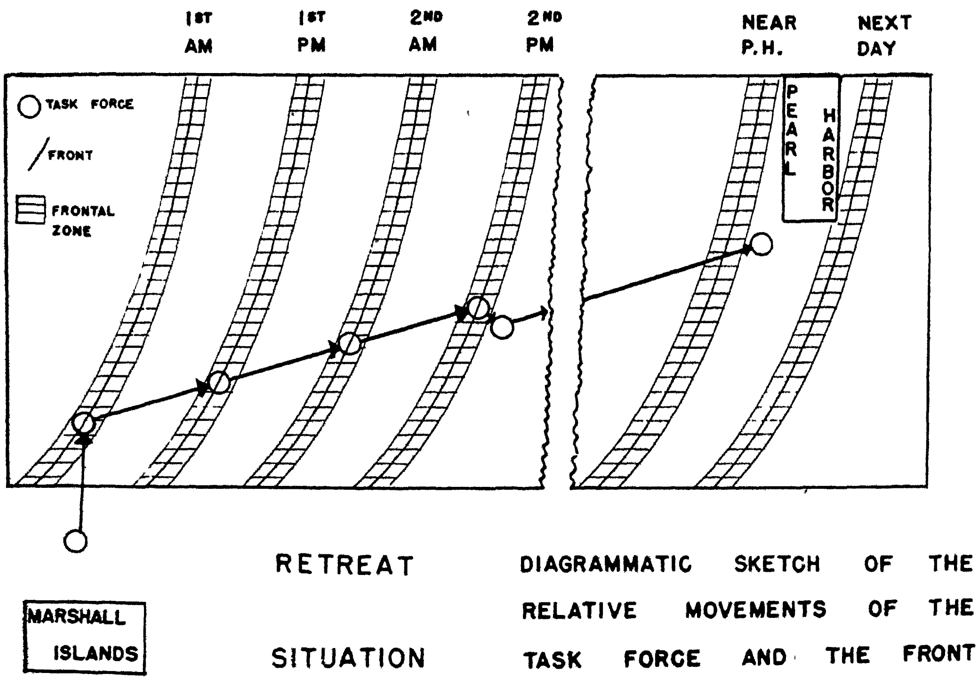

THE FIRST ATTACK ON THE MARSHALL ISLANDS

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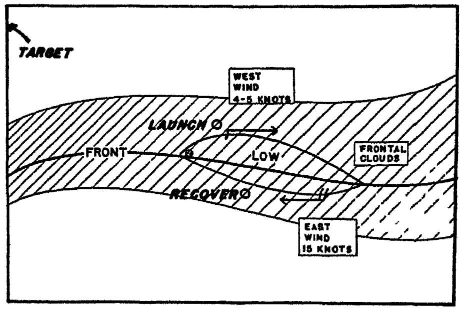

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attack Japanese positions in the wake of a typhoon before the enemy had the opportunity to prepare for defensive action. This was the case in the attack on Formosa. Sea, swell, and surf were forecast before each amphibious landing. Road conditions, dependent upon weather, were determined and taken into account in the over-all strategic plans. The forecast of the position of the equatorial front in 1943–1944 determined that the Gilbert Islands would be taken in November and the Marshalls in February.

Less dramatic than these tasks of naval aerologists but equally important because of its absolute routineness was the job of forecasting for air logistics. The war in Europe as well as in the Pacific depended to a great extent on air supplies. Every moment of flyable weather had to be flown. If fog with resulting zero-zero conditions was forecast for Stephenville, Newfoundland, by 3:00 P.M., a transport plane on its way to Europe via Stephenville could be cleared for flight only if it could reach that terminal before 3:00. The forecaster could not afford to be wrong. The war situation did not permit him to be over-cautious.

Aerological Progress During the War

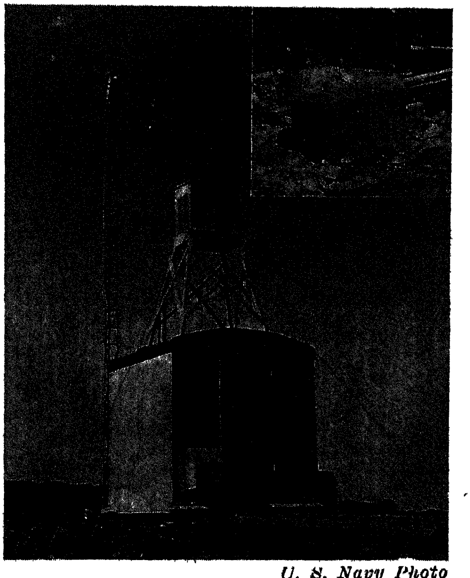
It should be noted that the aerological science met most of its obligations. It would be well to determine how this was made possible. Let us review the progress the science made during the war years.

Climatology. Much could be learned by reviewing weather records of the past. Units were established by the Army, Navy, and Weather Bureau to collect and analyze any and all weather data available from the beginning of weather records to the present. Tabulations were made of pressures, temperatures, rainfall, visibilities, cloud heights, wind directions, and velocities for geographical locations all over the world. Often as much as a year before any major action during the war, climatological records were assembled for use by the Joint Chiefs of Staff for tactical and strategic planning. Thus, in September 1944 these units worked day and night to give the requisite data about Okinawa. Not only were the figures given, but summaries were prepared under some of the following headings: Number of days per month suitable for high-altitude bombing, for low-level bombing, and for the use of incendiary bombs; sea and surf conditions by months in accordance with whether the winds were in the northern octant, in the northeastern octant, etc. The probability that a day of rain would be followed by another day of rain was calculated. Every possible interpretation of the data available was made to aid the strategists who planned the progress of the war. Enemy records as well as Allied records were combed for information. Eventually, again as a joint effort of the major activities interested in weather, a project was initiated to put all the available climatological data in the more readily useful form of punch cards. Since weather does not differ too much from year to year, climatology proved a valuable aid in the prosecution of the war.

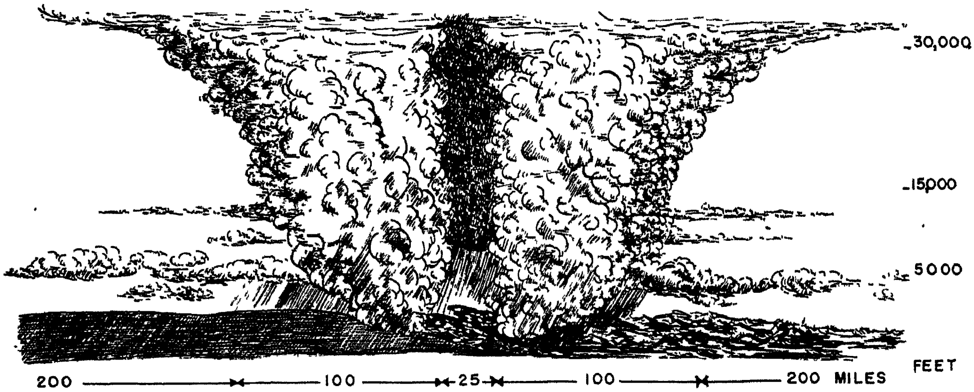
Long Range Forecasting. A forecaster usually feels a considerable degree of confidence in a forecast extending for 24 hours, and, although confidence decreases somewhat with time, he feels able to prognosticate weather conditions for a period of 36 hours. Beyond that, he may or may not hazard a guess but if he is honest he will label his forecast a guess or use the euphemistic term "outlook." For operational purposes under war conditions, the 36-hour period was frequently insufficient. A major offensive action required greater advance notice of favorable conditions. Troops

and supplies could be held in a state of absolute readiness for attack for only a very limited time. To meet this requirement, the Army, Navy, and the Weather Bureau each created a long-range weather unit. These three units working in close collaboration studied weather patterns and statistical correlations to the end of being able to predict weather for a period of five days. In many cases, their success was outstanding.

Weather Networks. To a great extent the accuracy of a weather forecast is a direct function of the density of the weather-reporting network. With the outbreak of the war, weather units were established in many geographic localities where reports were deemed necessary but had never before been available or at best had been too sparse. The Aleutian Islands and Greenland each got their quota of weather stations. As each Pacific island or atoll was taken, weather units were established. Occasionally, several days before public release of a landing was made, the aerologist learned of the action because a new weather report came in at a latitude and longitude indicating former Japanese-held territory. It almost seemed as though the rainmakers, as the aerologists are called throughout the service, landed with the first assault troops, setting up their anemometers and wind vanes and barometers before the beachheads were well established. When weather reports were required from within enemy-held territory, submarines or PT boats were sneaked into the dangerous waters, returning eventually with the requisite data. Aircraft were also assigned the mission of getting the weather. In cooperation with the Chinese and Russians, American weather stations by the dozens were established on the Asiatic mainland. This was necessary since the normal movement of the weather systems from west to east made knowledge of Asiatic weather vital for operations in the western Pacific. One technique employed, a war development which shows great peacetime potentialities, involved the setting out of automatic weather stations. These are units of either land or buoy construction which contain weather-measuring instruments. The instruments operate a radio according to a fixed schedule. As an automatic weather station goes on the air it gives its call letters in Morse code and then a series of dashes. The first series of dashes indicates atmospheric pressure. A radio operator, perhaps 500 miles away, can count the number of dashes and translate that number into the pressure observed by the barometric element of the automatic weather station. Wind direction and velocity, temperature, and amount of precipitation follow in the same way. These automatic weather stations can operate for a period of three months without any attention. They can be set out in isolated land or ocean areas where it would be impractical to establish and maintain a manned weather unit.



U. S. Navy Photo
AUTOMATIC WEATHER STATION



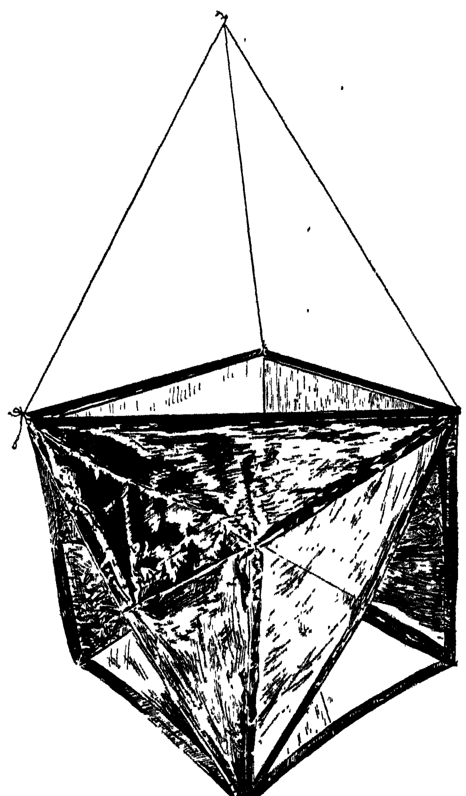
SCHEMATIC CROSS SECTION OF A TYPHOON OR HURRICANE

Another significant development which may possibly be treated under the general heading of weather networks is the matter of hurricane and typhoon reconnaissance squadrons. Before the density of the weather network was so greatly increased it was thought that only a half dozen or so typhoons raged through the Pacific during a year. During the war it was established that some two dozen storms might occur each year. This knowledge resulted entirely from the fact that now typhoons are observed, whereas earlier they went through their life's cycle without detection. With our fleet everywhere, each typhoon was significant. The motion of these cataclysmic tropical storms is usually erratic, however. To determine the course of an individual storm, it is necessary to see it and track it. Aircraft were assigned to the specialized duty of tracking these storms. Weather reconnaissance squadrons were established. A plane, upon hearing the report of an incipient tropical storm, would fly out into the region where it was reported, find it by means of the mammoth clouds associated with it, and then—such is the wonder of aircraft achievement—fly into the center of the storm. These planes would brave the 150-knot winds which form the circumference of the hurricane or typhoon to get into the calm center, or eye. Once within the eye, they would radio back their position. As long as they remained within the central portion, the position of the huge cyclone was established. Later radar, ship-, land-, or aircraft-based, aided in the tracking.

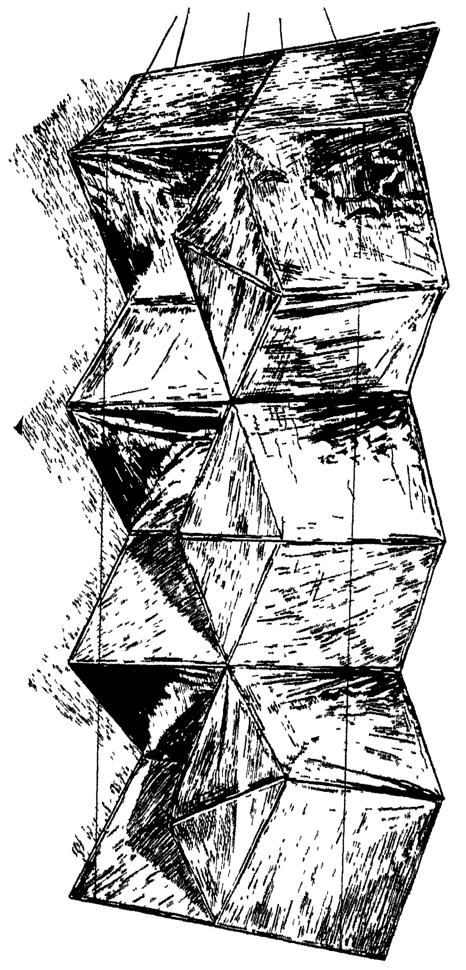
Microseisms. One has but to read a report of the destructive force of a typhoon or hurricane to realize how significant a part one plays in weather. Earlier, mention was made of sending planes to scout for an incipient storm. It was vital that each be detected at the earliest moment. Weather-reporting units on ships or islands found the first signs of some. Others would have escaped notice for several days had not use been made of a fact long known but never before investigated or put to use. A seismograph set up for recording earthquakes always shows minor vibrations even when no quake is known to occur. These are called microseisms. In recent years it was established that microseismic activity resulted from the action of a severe storm on the sea. Moreover, microseisms are directional. A microseismic station can take a bearing on the storm producing the phenomenon. At present the bearing is used in directing a plane in its search for the storm. Eventually, several microseismic stations, each taking bearings, will be able to locate the storm by

finding the intersection of these bearings. Microseismic stations were established both in the Caribbean and in the Pacific. The birth of a hurricane or typhoon did not escape the notice of the pendulum of the microseismograph.

Rawins. It seemed inevitable that radar, which played such a tremendous part throughout the war, would find weather applications. Actually, two great contributions were made to this science by radar techniques. Radar wind soundings—"rawins"—is the first of these. The great pressure systems which determine the weather are steered by the upper air currents. To forecast effectively it is necessary to know wind directions and velocities at 5,000, 10,000, and 20,000 feet. Formerly, a helium-

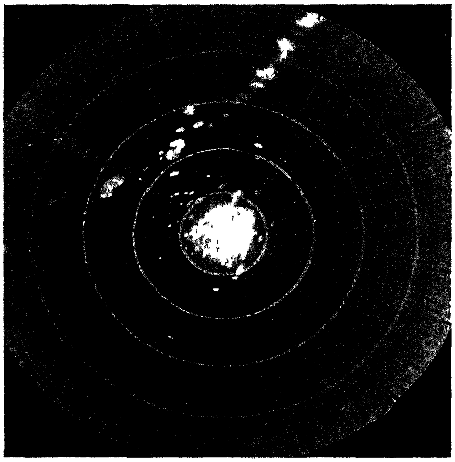


RADAR REFLECTOR
A SMALL REFLECTOR FOR RAWIN DETERMINATION.



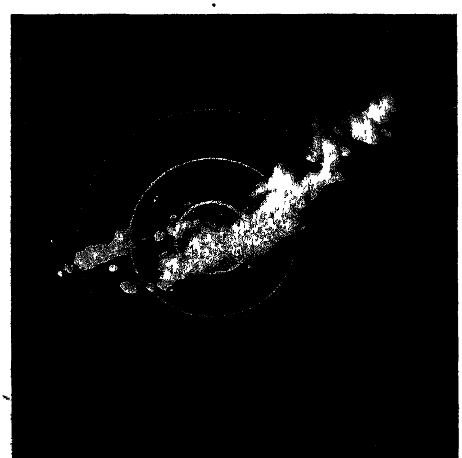
RADAR REFLECTOR
A LARGE REFLECTOR FOR RAWIN DETERMINATION.

filled balloon was released and tracked optically by means of a theodolite. This adaptation of a surveyor's instrument gives angles of elevation and azimuth when focused on the balloon. On the assumption that the balloon rises at a constant rate and that its horizontal trajectory is a function of the wind direction and velocity, these can be calculated at any desired altitude in the atmosphere. The difficulty was, of course, that when weather conditions are bad—when there is a low cloud cover—optical tracking is impossible. Need-

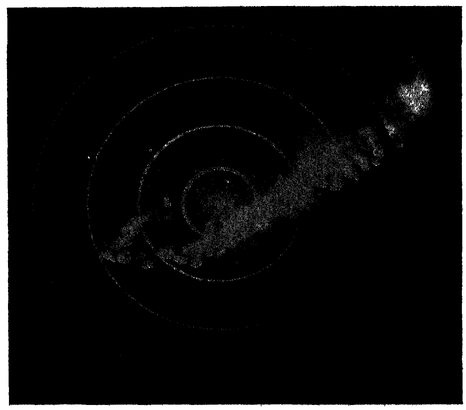


U. S. Navy Photo
A COLD FRONT
REPRESENTED BY THE ROW OF BRIGHT DOTS ALIGNED IN A NE-SW DIRECTION AS IT APPROACHES NAVAL AIR STATION, LAKEHURST, N. J., IN THE CENTER. THESE DOTS ARE THUNDERSTORM AREAS THE RADAR RANGE COVERS 50 MILES. THE CONCENTRIC CIRCLES INDICATE 10-MILE INTERVALS.

less to say, when weather conditions are bad, upper-air soundings are most necessary. It was discovered, however, that by hanging a reflector from the balloon, a radar pulse could seek out the balloon and track it even under the most adverse weather conditions. A transponder, or pulse repeater, suspended from the balloon could pick up the original radar pulse and amplify it before returning it, thus permitting tracking to far greater altitudes, under stronger wind conditions, and to far greater distances than ever before. Not only did upper-air wind soundings become possible under any and all weather conditions, but also radar added one more parameter to those normally determinable. Range is given as well as elevation and azimuth. The crippling assumption of a constant rate of ascent of the balloon was eliminated.



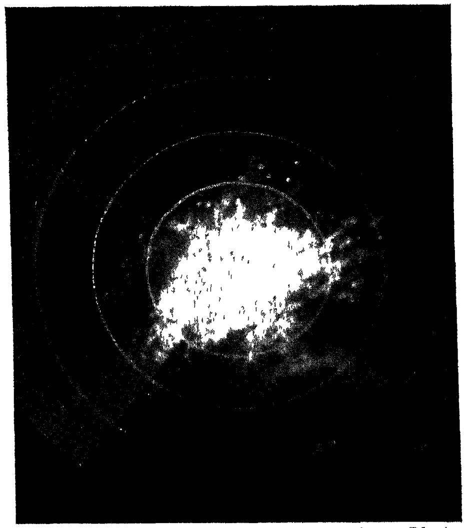
U. S. Navy Photo
THE SAME COLD FRONT AS IT PASSES LAKEHURST.



U. S. Navy Photo
THE SAME COLD FRONT
ONE AND ONE-HALF HOURS LATER.

Radar Storm Detection. The second great radar contribution stemmed from the discovery that frequently a pip was observed on a radar scope which could not be accounted for by approaching aircraft. The echo appearing on the plan-position-indicator (the PPI scope) had too irregular outlines, too great an area and height, to result from reflection from ships or planes. It was determined that precipitating clouds produced these echoes. The implications of this discovery were immediate and obvious. The approach of frontal systems could be observed 150 miles away. A single thunderstorm cloud could be tracked across the country. The approach of "weather" could be timed exactly. Air-

craft could be directed to thin spots in a front or around a cumulonimbus cloud and thus be able to fly through weather formerly considered impassable. The limitation of range of radar due to the boundary of the optical horizon was counteracted when necessary by placing the radar in aircraft. The radar pulse originating within the plane was not stopped short by the optical horizon. If needed, the information contained in the weather-produced echoes on the plane's PPI scope could be relayed to the ground. The Weather Reconnaissance Squadron planes were all equipped with aircraft radar suitable for storm detection. In their search for typhoons and hurricanes, the planes were greatly aided by the characteristic radar pattern of the clouds surrounding these storms. It no longer was necessary to fly into the center. The calm, precipitation-free eye of the storm appeared as an echo-free circle within the spiral configuration of the tropical storm's clouds.



U. S Navy Photo

A HURRICANE

AS IT FIRST APPEARED ON THE RADAR SCOPE AT LAKEHURST, N. J., SEPTEMBER 14, 1944.

Prognosis

Some of the war-evolved techniques have been discussed. To carry the analogy of meteorology's development somewhat further, the question can be raised: "Has meteorology achieved full maturity?" The answer must be No. Meteorology has done a man's work but has not yet achieved manhood. Look at its record during the war years. Almost all the progress has followed the direction of data collection. Whether it resulted from climatological records, the statistical correlations of long-range forecasting, aircraft reconnaissance, or the new radar techniques, the end product has been data and yet more data.

The progress of any science has always before followed the same general lines. The collection of facts has been only the first step in its development. The second resulted from deductive reasoning whereby the facts were sorted, classified, and summarized into equations. Finally, by inductive processes, new equations for natural phenomena are developed. Only at this stage of development can a science be considered fully matured.

At present, meteorology has more facts than it can use to the fullest extent. With the urgent need to investigate the upper atmosphere in connection with atomic research, guided missiles, and the rockets program, this situation is becoming further exaggerated. It must be understood that data are valuable—the more data, the greater the value. But the collection of data is not to be confused with an end in itself.

The correlation of data is the desired end. Eventually, weather forecasting must be resolved into a series of formulae which will permit the neophyte in the science to insert proper values of the variables into a series of equations. He can then solve for x and get the forecast weather. Only when mathematics, substituted for experience, can provide a forecast will meteorology have progressed significantly as a science.

Since these are days of electronic in-

ventions, the goal for which meteorologists must work is already in sight. Whereas formerly the solution of a problem with as many variables as atmospheric physics would have been deemed impossible, at present there are available electronic calculators to give the solutions. These machines are capable of solving some 100,000 differential equations a minute. Had we the proper equations to impress on the machine, we would need only to feed in the synoptic data and take out the weather forecast for one, two, or five days.

More than that—weather at any given locality is undoubtedly a complex function of variables at other geographic locations. Whether Washington, D. C., experiences rain next Tuesday may depend upon the temperature in Greenland now, the pressure in the Antarctic last year, the rainfall in the Mojave Desert last month. It is not inconceivable that with the energy of atomic fission harnessed and available, it will be possible to alter any one of these conditions and change the weather experienced at the capital at will. This would be feasible only if it could be ascertained where the energy could be most economically applied and what the effect of such changes would be on all other parts of the world. The rapidity of calculation of the electronic calculator would permit fulfillment of these two requirements.

But first the fundamental equations which determine the circulation of the atmosphere must be developed. Present-day meteorologists recognize the need. The Navy, for example, is sponsoring fundamental research on cyclogenesis, vertical motion in the atmosphere, heat exchange, and many other weather-related problems. With unimpeded progress in the collection of data and fundamental research in the physics of the atmosphere, meteorology should soon come of age.

THE HAKLUYT SOCIETY: ITS FIRST HUNDRED YEARS

By CHARLES F. MULLETT
DEPARTMENT OF HISTORY, UNIVERSITY OF MISSOURI

QUITE unobtrusively in 1846 a most significant learned Society came into existence and this year celebrates its first centennial. While no attempt will here be made to survey its whole career or to describe its full importance, it is submitted that the occasion does warrant attention. In the midst of national chaos and international anarchy the birthyear of a Society "for the purpose of printing rare or unpublished Voyages and Travels," a Society which sought by this means to open "an easier access to the sources of a branch of knowledge, which yields to none in importance, and is superior to most in agreeable variety," is likely to pass unnoticed save in the narrowest circles. Yet through the years—and none can deny that 1846–1946 has seldom been surpassed as a century of change, crisis, and indecision not only in material but in spiritual and intellectual matters as well—the Society has continued to meet for the discussion of what at times seemed esoteric, almost whimsical, problems and to publish or sponsor well over 200 volumes of what must often appear to the hasty as no more than antiquarian folklore.

With its inspirer, Richard Hakluyt, Preacher (1552?–1616), the Society has been both historian and geographer. Its narratives of travelers have acquainted students "with the earth, its inhabitants and productions." They have exhibited

> the growth of intercourse among mankind, with its effects upon civilization, and, while instructing, they at the same time awaken attention by recounting the toils and adventures of those who first explored unknown and distant regions.

So unobtrusive was the Society in its founding and career, however, that one will look in vain for any formal account of its purpose and philosophy beyond the few scattered phrases here quoted.

Without fanfare it published its first volume in 1847 and has kept doggedly at this function ever since. Wars may come and depressions may go, but the Society has pursued its way with scarcely a reference to passing events. In his preface to *The Voyage of Sir Henry Middleton to the Moluccas 1604–1606* (1943), the Society's president and a most distinguished historical geographer, Sir William Foster, did permit himself to observe that "the countries with which it is chiefly concerned (and several others) have been overwhelmed by a yellow flood of Japanese invasion. No one doubts, however, that this phase is merely temporary. . . ." Therefore, why should one, Sir William seems to inquire, disrupt and distort the true proportions of the past by interpolations on circumstances so temporal as a Japanese occupation? Art (that is, Clio) is long, invasions are but fleeting phenomena. Likewise, no apologies about the interruptions and shortages caused by the war in Europe and Asia mark this or any other volume. The eternal verities are much more significant. In 1916 the Society commemorated the 300th anniversary of Richard Hakluyt's death. The president, Albert Gray, in his address had no hesitation in giving the "lamented death" of Sir Clements Markham, who for 60 years had endowed the Society with his unwearied labors in editing and translating, as much consideration as "the dark cloud of war": they shared a sentence. From this he passed quickly on to mention the forth-

coming publications and to discuss informally "the place of Hakluyt and his great work in the political and literary history of England."

The remarks in the following pages have value in that they apply alike to Hakluyt and to the Society which bears his name. *The Principal Voyages, Traffiques and Discoveries of the English Nation made by Sea or over Land to the most remote and farthest distant quarters of the earth, at any time within the compass of these 1600 years* (12 vols., Glasgow, 1903–5) "may be regarded from the point of view of history, from that of literature or from that of empire building, and it is notable in all these aspects." Furthermore, Hakluyt's epic work may also be regarded as a notable example of the Elizabethan outlook, an outlook which interestingly enough found substantial and vivid exposition in the writings of Clements Markham's own Elizabethan ancestor, Gervase Markham (1568–1637). This outlook was one of curiosity, an industrious curiosity which led to the exploration not merely of unknown or little-known lands but also of equally unknown or little-known fields of knowledge, a curiosity which sought on every side to orient theory in experience, to test by specific observation or experiment the common generalizations.

Yet with Gray one may ask: Could "the editor of a compilation of traveller's tales, mostly transcribed, perhaps partly written to dictation, be classed as a historian . . . or . . . be placed in the world of letters in the rank of authors?" Hakluyt's own work was "little beyond the prefaces and dedicatory epistles"; and he never claimed to be more than a humble editor who rescued from oblivion records that "lay so dispersed, scattered and hidden in several hucksters' hands that I now wonder at my selfe to see how I was able to endure the delayes curiosity and backwardnesse of many from whom I was to receive my originals." Fortunately the patriotism, curiosity, and no doubt sheer enthusiasm of one who was both Herodotus and empire-builder kept Hakluyt going. The result is the prose epic of the English nation, heroic deeds nobly told.

The Society has adhered not ostentatiously but quietly and naturally to Hakluyt's own qualities. From the first volume, *The Observations of Sir Richard Hawkins Knight, in his Voiage into the South Sea Anno Domini, 1593* (1847), down to the aforementioned *Voyage of Sir Henry Middleton* (1943), the editor has kept very much in the background. The original narrative is the thing. The editor of the *Observations*

> confined his labours to reproducing the text of the original, with only such slight observations as were necessary where the sense of the author had been obviously marred by a misprint [he was reproducing the printed text of 1622]; giving such explanations of obsolete words and technical terms as might embarrass an unprofessional reader; identifying the places visited with their modern appellation, where practicable; and adding such remarks as occurred to him while correcting the proof sheets.

The introduction included sound but brief reference to the hazards of voyaging in Elizabeth's day, the equipment of the ships, the administration of expeditions, the career of Hawkins, and the consensus of opinion that the *Observations* "must take their station in the very first rank of our old sea voyages."

The editorial work and the introductions a century later are somewhat fuller, but this follows less from the intrusion of the editor than from present-day historiographical tendencies. In 1943 Foster produced a text "with the addition of such other contemporary material as could be found, bearing upon the voyage." His lengthy introduction and notes supplied the Elizabethan background, political and economic, related the voyage of Middleton to contemporary naval and commercial developments, de-

scribed the organization of the expedition, discussed other English activity in the Far East, commented on Dutch rivalry, informed readers about Middleton, listed some bibliography, and elucidated and identified some terms and places. Nonetheless, the narrative, no matter how heightened its meaning through such loving care, is still the thing.

When the Society was founded in 1846 it set forth in the first article of its few laws the guiding purpose:

> The object of this Society shall be to print, for distribution among its members, rare and valuable Voyages, Travels, Naval Expeditions, and other geographical records, from an early period to the beginning of the eighteenth century.

The only deviation from this modest yet comprehensive policy has been the elimination of the terminal date, for occasionally volumes have dealt with the eighteenth and early nineteenth centuries. The other articles covered such mundane matters as subscriptions, organization, administration of the Society's affairs, and rules concerning publications, the individual editors of which receive nothing more than 25 copies of the published work.

Throughout the years the Society briefly reported its ups and downs in membership, its publications, past and prospective, its financial status, which seems generally to have been good, its officers, and on occasion the passing of some distinguished members. At the beginning it numbered somewhat fewer than 250 members, but among them were men of substance in every field of endeavor—admirals, bishops, politicians, businessmen, and scholars. John Barrow, the assiduous promoter of Arctic exploration, Charles Dickens, Sir John Herschel, and William Whewell were charter members. The subscription fee of one guinea which entitled members to receive the publications was certainly not prohibitive for those interested; it has not been increased. In 1849 the Council could report a membership of 276 and a generally cordial reception, private and public, for its publications. At the end of the first decade the subscribers totaled about 320, but thereafter the number declined and remained discouragingly low for several years. In 1873 it was 214; in 1878, 248; and in 1889, 278, the Society seeming to suffer from the preponderance of older men among its members. After 1900 a definite upturn was obvious, and the Society was then in a position to carry through more of its publication projects, which were intended to be at least two a year. In 1930 the membership exceeded 630, many of which were libraries and societies.

Large or small, however, the Society could with complete accuracy declare in 1901 that it had "not confined its selection to the books of English travellers, to a particular age, or to particular regions." In time it ranged from the thirteenth to the nineteenth centuries, with greatest emphasis on the 150 years after Columbus, and in space it covered the world. As this catholicity became increasingly apparent and was consistently adhered to, subscriptions began to come in from an ever-widening area until the membership was as completely international as the substance of its publications. Nevertheless, its high standard of historical purpose did not deter the Council from taking pride in 1865 in the practical value of a volume on the early exploration of Hudson Bay, which had provided Captain Penny, then in search of Sir John Franklin, with his most complete navigation guide for part of the Hudson Bay region: so the travels "may often be of real practical use to seamen and explorers."

In the largest sense the value of the magnificent series is of course primarily historical. We may agree with the foremost authority on the subject, J. A.

Williamson, that the "history of Elizabethan expansion is to a great extent the work of Richard Hakluyt, to a greater extent perhaps than the record of any other large movement can be ascribed to the labors of any one historian." But the truth of this can be fully realized only if attention be paid to the work which Hakluyt inspired. In contrast to Samuel Purchas, B.D. (1577–1626), who in *Hakluytus Posthumus or Purchas His Pilgrimes. Contayning a History of the World in Sea Voyages and Lande Travells by Englishmen and others* (20 vols., Glasgow, 1905–7) attempted to carry on his work, Hakluyt was an almost perfect editor. He "gathered the materials of a history and dealt so cunningly with them that they became a history while retaining their guise of raw materials"; but Purchas "arranged a museum." Notwithstanding his great merits—and only reading will reveal them—Hakluyt was not complete, and it is the peculiar virtue of the Society which bears his name that it has performed a miracle; it has successfully and appropriately gilded the lily. Without the Society, as indeed without the empire resulting from the expansion he at once narrated and encouraged, Hakluyt would have received far less consideration.

The Hakluyt Society publications, like those of Hakluyt himself, are not to be viewed exclusively from the standpoint of expansion. While it would be tedious to list the publications, one must emphasize the range. The narratives of French, Dutch, Spanish, Portuguese, German, Italian, and Danish, as well as English, travelers are reproduced. These men, representing a wide variety of professions and vocations, visited Europe, Asia, Africa, the Americas, and the islands of the sea. Neither tropic heat nor arctic cold stayed their steps. From their accounts one may learn much of the history and society of the countries visited, much of the expansion process, and, perhaps most important of all, the outlook of the travelers and by extension their lives and times. Indeed the voyages and descriptions here published convey deep insight into contemporary European social and intellectual conditions. They are particularly valuable for reconstructing the scientific, the moral and religious, and the broadly social views held by the travelers themselves and the environment from which they sprang. No one wishing to grasp to the fullest the history of the period in which these narratives were first composed should neglect them.

These visitors to other worlds, whether merchants, priests, diplomatists, or mere wanderers, genteel or otherwise, on the face of the earth, constantly faced natural phenomena, political and social institutions, and currents of opinion the like of which they had never encountered before. Inevitably they compared and contrasted and not infrequently, as they penetrated to the essential core of their discoveries, they remarked similarities to those things they had known at home. Furthermore, though they knew it not, they were in their own way following the precept of that great twelfth-century explorer in various realms of science, Adelard of Bath: "It is worth while to visit learned men of different nations, and to remember whatever you find is most excellent in each case." If learning as Adelard knew it was seldom present, knowledge abounded.

The epic accounts preserved in Hakluyt, Purchas, and the volumes of this Society—not to specify the many other handsome collections—provide a majestic autobiography of an age, fascinating and comprehensive. How and why these men of whatsoever origin and interest set down their reactions to the worlds of their explorations is part of the essential history of the countries they represented; what they described belongs to the history of worlds overseas. The whole is a magnificent panorama of world

history. From the outset, the urge of travelers to keep diaries or to write up their experiences on returning home has been natural and prolific. Many of these immediately became available in the pages of Hakluyt, his successor Purchas, in other collections, or in isolated publications. The special distinction of the Hakluyt Society has been the completeness and the authority with which such diaries and accounts have been gathered up, given dependable editorial sponsorship, and made generally available in an intelligible dress. It is scarcely too much to say that the unknown has become known, the rare has become common, and the incomplete and mutilated has become complete and restored.

The products of course have an interest all their own. The motley crew of adventurers had personality. Some were extraordinarily skilful narrators, others extraordinarily unskilful, at least so far as superficial trappings were concerned. Whatever their quality in this regard, however, their experiences and characters alike transcended syntax, and, so far as English travelers were concerned, their narratives are often "admirable examples of English prose at the stage of its most robust development." The bizarre and the commonplace, the journey and the destination, the land and the people, the ideas and the institutions, leap from their pages. Not all they wrote can be taken as truth, but they assembled the ingredients of truth. Samuel Purchas was no doubt a bad editor in many ways, but he fully saw the importance of geography for history. Moreover, his declaration that "the necessitie of a Historie is, as of a sworne Witnesse, to say the truth, all the truth (in just discretion) and nothing but the truth" derived in no small measure from his appreciation of the value of those divers journals he pored over so assiduously. The Hakluyt Society volumes add bountiful substance to his contention, but like those very volumes, no small part of the Society's value is the outlook its activity and devotion reflect. A learned Society with one hundred years of history stands as a beacon light in a stormy world. May our grandchildren celebrate its second centennial!

PHYSALIA

The hydrozoan spew of earth's pelagic womb
Produced Physalia, queen coelenterate,
An iridescent flagship, fringed, globate,
To lead each year's armada to its doom.

From freedom of the sea's wide lane
Wind driven, the pint-sized Man of War
With sheer topsail and frail pneumatophore
Becomes a bauble which the sand crabs claim.

A tropic quiet marks the listless day
While bathe in tidal pool, the fair
Of face and limb, unconscious where
The ten-foot strands of poison stray.

An accidental touch everts each sac
Of barbed nematocyst. In seried rows
Like branding rods the acid protein grows
A livid trail to mark the dread attack.

No mean opponent this whose thousand darts
Of liquid fire retain their venom, dry
For months, whose jellied forms belie
The shock and torment which their sting imparts.

With neural net of prime simplicity
Predating brain, and vascular canal
Predating heart this gastral sac
May shed some light on our duplicity.
So close beneath the skin the bestial!
To look like gods and yet so much to lack!

JOHN G. SINCLAIR, 1946

THE HERBARIUM

By F. R. FOSBERG

SCIENTISTS have two great sources of information. One is, of course, scientific literature. This is the record of observations and conclusions of workers since science began. Because it is recorded information it must be regarded as a secondary source. It is subject to a considerable increment of error because it has been written down by the human hand. The same increment is also inherent in the raw data recorded from experiment or field observation.

The only primary source is in the actual objects of study. In astronomy this source is in the heavens and is accessible by means of telescopes and cameras. In geology and geography it is the earth. In physics it is the universe, from the infinitely large to the infinitely small. In chemistry it is the multitude of combinations of the elements that make up the tangible universe. In ecology and its branches it is the biotic community that covers the surface of the earth. In anthropology and its subdivisions (psychology, sociology, ethnology, archeology, etc.) it is man and his works. In biology it is organisms.

One of the principal problems in each of the sciences is that of gathering together in accessible form the objects of study. The problem is sometimes partially solved in most of them by photography. The limitations of this method make it, at best, a partial solution. In most branches of science recourse must be had to collections of recorded data, thus introducing the increment of error. In a fortunate few the museum affords a practical means of concentrating in one place and in convenient form for study primary materials from over the entire earth. It is natural history (which may perhaps be defined as the unexperimental part of biology) that has, by the very nature of its objects of study, been enabled to make the fullest use of the museum as a tool. Of course, there are many other sorts of scientific museums, mostly pertaining to certain branches of anthropology and geology. In some of these (that, is archeology, history, mineralogy, petrology, paleontology, and physical anthropology—the last two equally branches of biology or natural history) the museum is the basis of most research. However, even in one or two of these, difficulties are inherent. Architecture, airplanes, and other large machines are expensive and difficult to house, while physical anthropological material is often subject to certain emotional associations that make its acquisition difficult.

It is in biological taxonomy that the museum reaches its fullest development and its greatest usefulness. It is here at the very roots of the entire science and of its utility to other branches of science and human activity. The concentration of material from many places and its subsequent preservation frees the science, in a large measure, from the tyranny of words and the errors that occur in their recording, use, and interpretation. A taxonomic work that is based upon a properly collected and preserved series of specimens need not depend for its entire value upon the words in which it is expressed or the conclusions drawn by its author. The specimens which are its foundation will last indefinitely and may always be examined, if they are so cited as to be identifiable.

The special type of museum to be considered here is, for historical reasons, called a herbarium. Early systematic

botany was preöccupied with medicinal plants, generally termed herbs. It also grew up in a part of the world where much of the flora was composed of grasses and other herbs, as opposed to shrubs and trees. One or both of these facts may have influenced Linnaeus in the coining of the simple and usable word *herbarium* for what had previously been variously called a *hortus siccus, hortus mortuus, hortus hiemalis,* or *phytophylacium.* At any rate, it may be due to these predisposing causes as well as to the position of authority of Linnaeus that the word was generally taken up by the botanical world and is in universal use today.

With proper preparation and adequate care dried plant specimens will last indefinitely. The herbaria of Ghini (1519–1556) and Caesalpinus (1519–1603) were, at the beginning of the second World War, still in existence in Italy. Pressed specimens attached to uniform-sized sheets of paper also lend themselves to filing. The part of the paper not covered by the plant is inevitably, and properly, used for jotting down observations for future reference of the person making them or to direct attention of future workers to peculiarities of the specimen.

In brief, the modern herbarium is a great filing system for information about plants, both primary in the form of actual specimens of the plants and secondary in the form of published information, pictures, and recorded notes. An important part of the herbarium is the staff of botanists and other workers who use it and make it function.

Literally speaking, any collection of dried plants prepared for study is a herbarium, no matter how it is arranged, filed, or preserved. However, several hundred years of experience have resulted in more or less standard methods being evolved, to such an extent that a botanist from one herbarium is quite at home in any other, and specimens are exchanged between them perfectly satisfactorily, as well as lent back and forth.

Pressed plant specimens are mounted on standard-sized sheets of heavy white paper, with the label in the lower left-hand corner, placed in manila folders, one species in a folder, these in heavier folders, one genus to a folder. These are filed in upright filing cases of a more or less uniform design, with pigeonholes to fit a convenient number of specimens. There are several systems of arrangement, all familiar to any botanist, so that there is seldom any difficulty in finding the specimens of any desired species.

This system is ideal also for the inclusion of notes, photographs, drawings, plates, and clippings from published literature, which are mounted on similar sheets of paper and filed under their proper family, genus, or species.

Under the ministrations of a competent staff, there is a continual influx of plants, photos, and information of all sorts. The main source is, of course, field work done by the members of the staff. Specimens are collected not only for inclusion in the herbarium, but so that duplicates may be exchanged with other institutions, bringing a flow of specimens from them, along with the benefit of the experience of other botanists as contained in the identifications and notes on these specimens. Thus the effectiveness of each botanist is multiplied and his knowledge and experience made widely available. Specimens also come in for identification. The services of the botanists of most herbaria are always at the command of anyone who will take the trouble to send in a good specimen of any plant that he wants identified. The plant, if it is properly pressed and accompanied by data as to place and circumstances of origin, is usually placed in the herbarium. Most

botanists are specialists either in one or more groups of plants or in the flora of a particular region. Because of this, specimens are sent to him from institutions and individuals all over the world to be identified and added to the herbarium in which he works. Thus, in return for a service which could be found nowhere else, he is given access to much more material of his specialty than he could ever hope to collect by himself. And the accumulation of information in his institution grows.

One of the most important functions performed by a herbarium is that of preserving and caring for valuable historically important specimens. These are largely what are called types. Types are specimens upon which species have been based and which are thus the points of reference for the names given to these species. However inadequately the species may have been described or whatever the changes undergone by the meanings of words, if these original specimens are preserved and available, all doubts as to the application of their names are avoided. Such specimens are, of course, irreplacable, and their care is perhaps the most important single responsibility of any herbarium to which types are entrusted. They should be regarded as a part of the general heritage of the science of botany, rather than as the private possessions of any one institution, regardless of their legal status. Special techniques are employed in their preservation and special procedures worked out for their use and availability. An increasingly important modern practice is the exchange between herbaria of photographs of types and other important specimens.

The activities of the staff members roughly classify themselves into two interlocking categories. First is the securing and incorporation of material into the herbarium. This includes everything from collecting specimens in the field to filing them away in the folders after they have been identified and mounted. The other sort of activity is the utilization of this great reservoir of information. Study and comparison of the specimens and correlation of the information obtained with what is already known results in a continuous stream of identifications, answers to questions from all imaginable sources, and publications making the results of this research generally available.

The continual flow of new specimens, questions, and requests for information is second only to the staff members' own field work in stimulating this search for new information and clarification of old. In the course of attempting to identify specimens and answer inquiries, gaps in our knowledge are encountered, defects in the classification, misinterpretations of fact, undescribed species of plants, unsatisfactory keys for identification. All of these are challenges to the active mind of the botanist. They may lead him far afield in his attempts to remedy the deficiency, but he is seldom satisfied until the task is done. And all the time new bits of information are being incorporated into the great body of fact that is the herbarium. The result is that a study of almost any group of plants in a large herbarium will yield a quantity of previously unsuspected information, made obvious and significant by being brought together in the continual process of organizing and adding to the collection.

UNTIL recently the herbarium has been regarded as the exclusive bailiwick of the purely systematic botanist. Those who dealt with living plants regarded the physiological laboratory as the only reputable place for such study. The outdoors was usually left to the systematist, who too often regarded it only as a source of herbarium specimens.

However, when the systematist began to realize that the units he was studying were really populations and that the fundamental principle behind his classifications was really evolution, and when the physiologist started to venture out into the field and to call himself an ecologist, the two sometimes met and talked. The more alert ones among them discovered that they needed each other to help answer some of the questions that their new contacts and concepts raised. Geneticists also arrived on the scene. They commenced to infiltrate the hitherto exclusive domains of the cytologists and the systematists as well as, once in a while, to venture also out into the field to examine their plants as natural populations. The different sciences came to lose their exclusiveness. The systematist began to lose his austerity, the followers of the newer branches to get over their inferiority complexes, and such hybrid individuals as experimental taxonomists, cytogeneticists, cytotaxonomists, and even cytogeographers made an appearance. The practical plant breeders smelled something that might be put to their purposes. When they showed an interest, a few of the keener botanists jumped at the chance to put them to work helping solve some of the fundamental problems that required several kinds of expensive effort.

One man, who is a happy combination of horticulturist and highly competent systematic botanist, has long been doing valuable practical work on cultivated plants in the herbarium. This is Liberty Hyde Bailey. Many others whose resources were much greater missed opportunities that may never come again to effect this union of two sciences for mutual profit, because of lack of the education or mental acuteness to see the possibilities.

It remained for another man, one who calls himself a geneticist but who is really one of the outstanding biological thinkers and scientific philosophers of our time, to demonstrate and to emphasize the fact that the herbarium should be a valuable tool and laboratory for many different branches of botanical investigation besides pure systematics. Edgar Anderson, in his writings on new techniques for population study and the analysis of variation, has pointed the way toward the herbarium of the future.

The task of the herbarium, which is still to be an organized collection of dried plant specimens, has suddenly grown from that of preserving series of specimens to show only the range of variation of species and their geographical distribution and vouchers for the fixing of names to a much broader scope. Mass collections to show population structure, range and distribution of variation, this in time as well as space; specimens of cultivated plants to document and provide comparative material for the work of the applied economic botanist or plant breeder; specimens which are vouchers for the work of the geneticist and the experimental taxonomist; material for intensive phylogenetic research; specimens of the abnormalities produced by the experimental physiologist; specimens which form the basis of ecological studies; and plants whose chromosomes have been counted or which have been the subject of important morphological and physiological investigations all now come within the domain of the herbarium's interests. There is a crying need for this sort of material to be preserved in an always available form and place. The herbarium worker has had four hundred years of experience in the technique that will satisfy this need. In the face of his reluctance toward change, this task is being forced upon him. It will be more and more forced upon him in the future. Willy-nilly he will be removed from his position of aloofness and

from the position of unappreciated and unrespected servant where he is placed by some of his colleagues. He will be forced to become a full and active partner in the enterprise of biology. The effects, both upon him and upon biology can be expected to be very healthful.

One of the most important tasks for the herbarium, more urgent than ever now that man's numbers have so increased and his destructive capacities have become so great, is the preservation of data on the original vegetation of the earth. It is being destroyed with tragic rapidity and with no regard for what interest it might have in the future. The only documented records that will remain of much of it will be on the labels and notes accompanying herbarium specimens. The rescuing of these data, the raw material of vegetation study and plant geography as well as of systematic botany, is perhaps the most pressing function of the herbarium and its staff. All collecting done is a contribution to this fund of information. Every herbarium worker should, if possible, spend a substantial part of his time collecting. Institutions maintaining herbaria should do everything in their power to make this possible.

Another very real, though perhaps unintended, function of a herbarium is to provide a meeting place for botanists. They are attracted by the collection of plants and by the accomplishments of the staff members and are thus brought into contact with one another. This provides an important opportunity for exchange of ideas and for mutual benefit from experience. The whole science gains from the stimulation to thought and from the mutual understanding and cooperation resulting from these contacts that casually take place in the herbarium.

Space and an adequate and continued income have always been the problems that have plagued the herbarium administrator. Herbarium buildings are, almost without exception, either buildings that have been built for other purposes and adapted or parts of university buildings that have been built to serve all of botany or biology. Few buildings have ever been designed as herbaria and all too few have been built with much thought for future expansion. Consequently the normal activities and interests of many herbaria have been cramped and stifled by lack of space. The basic income of most herbaria is provided by the institutions that maintain them. This is almost never adequate for full functioning of the herbaria. The difference, in those few cases where it has been made up, has been provided by gifts, either from patrons who have had an interest in the work of the institutions and their staffs or, in all too few cases as yet, from corporations and agencies who have profited directly or indirectly from the work carried on. Such gifts have been largely responsible for some of the greatest steps in the outstanding progress in taxonomic research and botanical exploration accomplished in the United States in the past half-century. It is to be hoped that with the broadening interests and utility of herbaria such gifts will continue and multiply many times.

Much of the success of a herbarium is dependent upon the personality and ability of its administrative head. The ideal herbarium administrator would be an outstanding systematic botanist with broad interests extending into many groups of plants, regions of the earth, and types of problems. This would give him a broad base for understanding the multitudinous activities of the herbarium and its different staff members. He would have a long-range viewpoint, realizing that any work, material, or money put into a herbarium is a long-term investment, expected to serve for ages.

He would seek out the opinions of all who had experience with a given topic or field. He would select staff members for demonstrated ability and interest in their work and would let this be their compulsion to work. He would have a genuine love for people as individuals and interest in them as well as an even disposition and the ability to remain unruffled by the inevitably strong individualities of his staff members. He would be able to regard the research problems and interests of his staff as of even more importance than his own and to place the interests of his institution as a part of the greater entity of biology above all else. Perhaps most important of all, he would be able to maintain friendly relations and cooperation with the rest of botany and with the public. And he would be able and willing to fight, when necessary, with his superiors, be they college presidents, regents, trustees, or governmental administrators, to see that his institution and staff were not hampered or restricted in following where their enthusiasm led them in their work. It would be a fortunate institution, indeed, that had such a director.

The characteristics of a herbarium may be summarized by regarding it as a great organism into which is maintained a flow of specimens and unorganized data. The staff of botanists, technicians, clerks, and other workers furnish the driving force and controlling influence. With an adequate staff and support the organism maintains an active growth. There is a continuous production of results in the form of services to other human enterprises and of additions to the general fund of organized knowledge that is science. Without these two requisites disintegration rapidly sets in, and the investment in effort, time, intellect, and money is wasted.

GOVERNMENT AND THE MEASUREMENT OF OPINION*

By SAMUEL A. STOUFFER
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LONG before the war social scientists were studying and documenting the proposition that society's greatest problem is to develop mechanisms of government adaptable to the complex social order produced by modern science and technology. And whether we like it or not, as has so often been said, big government is here to stay.

There is no less reason for us to fear big government today than in the time of Thomas Jefferson. But fear cannot reverse the technological trends which have substituted the airplane for the stagecoach. Our problem is not how we can prevent big government, but rather how, having it, we can keep it both responsive and responsible to the people. If the liberties which were slowly and painfully won through the long centuries of the history of Western civilization are to be preserved, government must be not only for the people but also of and by the people.

Big government can be responsive and responsible to the people only if there are efficient channels of communication between the governed and the governors. Let us discuss some developments of the past decade for the improvement of these channels of communication; developments which can prove of considerable importance to the preservation of our civilization. They are even yet in their infancy, but we have seen enough to get a foreshadowing of what they promise for the future.

How does Washington find out what the people are thinking? There are several channels.

One is the press and radio. We can admit that the press often represents the publishers' personal viewpoint and not the public's and still be thankful for the freedom it possesses. Abuses by government are not likely to go unchallenged or achievements of government undefended somewhere in print or on the air. Nevertheless, the press taken as a whole is hardly the voice of the people, as recent presidential campaigns have abundantly demonstrated.

Another channel of communication between the people and Washington consists of letters to members of Congress or executive officials. This freedom to write or petition is a precious one and is influential, but few would hazard the claim that such mail mirrors public opinion. When the future of American preparedness trembled in the balance in the summer of 1941, the House of Representatives voting by a majority of only one to extend Selective Service, a study of the Congressional mail showed that the mail was running 90 percent against extension of Selective Service in spite of the fact that public opinion polls showed the majority of the public in favor.

A third means of communication is face-to-face contact, often by the representatives of pressure groups. Statements like "I represent the view of 8,000,000 American women" or "This is what the farmers want" or the church people want, or whatever the group may be, are sometimes potent determiners of

* From an address before the St. Louis Meeting, A.A.A.S., March 28, 1946.

Congressional or executive action. It is the fashion among liberals to condemn lobbyists (except, of course, lobbyists for good liberal causes), even though it should be obvious that *organization* of opinion is necessary to get desired political action or prevent undesired political action. A just criticism, however, can properly be made of tricks of lobbyists in bluffing about what the public wants or will not stand for and in manufacturing synthetic public pressure through word of mouth, letters, and telegrams.

A fourth method of communication is, of course, elections, when the people have an opportunity to express their opinions by voting the rascals out or returning those whom they consider faithful servants. So many factors enter into a vote for a particular individual that it is seldom possible to interpret his election as a mandate from the people on a particular issue. In some states the expensive referendum procedure has been extensively used, sometimes with good results on issues which have been widely debated but with less satisfactory results on issues which are complicated and do not admit of a simple yes-or-no answer.

All these channels of communication, the press and radio, letters, face-to-face contacts, and elections, are obviously vital to operating a government responsive to the people, but seldom do they succeed in gauging according to any scientific standards of accuracy the degree to which the public is informed about an issue, the degree to which it is concerned, and the division of opinion on the issue.

The pioneer work of men like Dr. George Gallup and Elmo Roper have brought into public consciousness a fifth channel of communication which is already beginning to take its place alongside the others as a means of bringing the people and their government closer together. The idea of a public-opinion poll is an old one—straw votes have been taken for decades—but it is only in recent years that the procedures have been systematized. In so doing, the practitioners of polling have gone to the mathematical statisticians for help in devising the most efficient sampling designs. Much progress has been made in increasing accuracy at the same time that costs are reduced. Further progress may be expected. The National Research Council and the Social Science Research Council have joined hands in setting up a committee of mathematical statisticians, psychologists, sociologists, practitioners of opinion research, and important consumers. The first project of this committee, with the aid of a grant from the Rockefeller Foundation, is to review various types of sampling designs now in use and to explore the relative advantages and disadvantages of alternatives, theoretically and practically.

While the accuracy of opinion surveys depends on the selection of a representative sample of respondents, it does not depend alone on that. In fact, the sampling of respondents may be one of the relatively easier of the problems to solve. Even more important is the problem of defining the issue and selecting from the universe of possible questions which might be asked of respondents a sample of questions which will represent the attitude of respondents on that issue. Again, the mathematical statisticians have been making progress in formulating what is meant by sampling from a universe of items on a particular issue and in devising means of testing the consistency and representativeness of the items selected. Compared with the developments in the sampling of respondents, the developments in the sampling of items are still in a relatively primitive state. Much progress is to be expected in the next few years, and the joint committee of the National Research Council

and Social Science Research Council is naturally concerned with such problems.

It is to be expected that opinion surveys would be viewed with some suspicion by members of Congress and by other officials within the government. When Senator X stands on the floor of the Senate and says, "I speak with the voice of all the people of my great and sovereign state," he can be subject to considerable embarrassment if a scientifically designed poll shows that only 10 percent of his people think on the issue the way he does. In a sense, the very idea of a poll is an invasion of the sacred prerogative of members of Congress to be the spokesmen of their constituents. But Senator X may also have more legitimate grounds for suspicion. In the wrong hands, this new device for recording public opinion can be abused. It is possible for clever publicists to select certain items favorable to their side of a case, suppress others, and make a presentation in the name of science which is completely misleading. This has been known to happen in the commercial field, and the best practitioners are always on their guard against it. It could happen, and probably has happened, in government. The danger may be expected to increase as more and more leaders discover what a powerful instrument for influencing action a supposedly scientific analysis of the public will can be.

There are two further dangers of public-opinion polls which should be mentioned. One is the danger of jumping honestly but too hastily to the conclusion, from a reported survey, that the public mind is determined in a given direction. The other is the danger that polls will have too much, rather than too little, influence on governmental action. Let us take them up in turn.

First, the danger of jumping honestly but too hastily to conclusions from a reported survey: Polls taken shortly before the defeat of Japan showed that the American public was in favor of executing or at least dethroning Hirohito and that very few favored using him as a tool to carry out our occupation designs. Yet when Hirohito was kept on the throne there was no outcry against it from the people. Evidently, the original opinion expressed by the respondents was not an opinion based on a review of the contingencies and was not held with great intensity. The next few years in the development of public-opinion surveys are likely to see much progress in study design so that one can determine, more accurately than present methods permit, how well informed the respondents are about contingencies and so that one can estimate how the opinion could be expected to shift under different contingencies.

The need would seem obvious. Three years ago the Research Branch of the Information and Education Division in the War Department asked a representative cross section of soldiers whether they would like to get more education after the war. About one-third of the men said Yes. What a bonanza for the educational institutions! But wait—only 4 percent said they would go back to school if they could get a good job after the war and if the government would not provide any educational subsidy. (This study was made before the passage of the GI bill.) A further analysis of the responses led to an estimate that 7 percent would go back to full-time school, given a moderate government subsidy. This figure was used by the President and Congress in estimating the educational cost of the GI bill. Opinion studies in the Army subsequent to the passage of the bill raised Army estimates, but current figures on full-time school attendance by veterans are still only about 2 or 3 percent higher than the one prepared three years ago—

in spite of the fact that the educational subsidy is much more generous than originally contemplated.

The Division of Program Surveys in the United States Department of Agriculture has been outstanding in efforts to structure the situation in which a respondent is replying and get a basis for predicting what the reaction or behavior of an individual is likely to be under this or that contingency. The Division made studies during the war not only for the Department of Agriculture, but also for the Office of War Information, the Treasury Department, and other government agencies. A typical problem was that of war bond redemptions while the war was in progress. Studies showed, first, that most redemptions were for emergency purposes or capital outlay and not for buying consumer goods and, second, that the difficulty of redemption was inhibiting new purchases of bonds among small potential buyers. Careful questioning led to the conclusion that it would be safe for the Treasury to liberalize its redemption policy since it was quite likely, from an analysis of the responses, that increased bond purchases would far and away offset any increase in redemptions. This prediction was found to be correct when the Treasury, following the survey, liberalized redemption policy. During each bond drive Dr. Likert's organization made surveys of the motivations for buying, and many of the findings were directly used by the Treasury and the War Advertising Council. The important thing to note about such studies is that they require very careful advance analysis of the problem, the designing of indirect as well as direct lines of questioning, and a final analysis which depended on much more than the simple answers to a few check-list questions.

The Office of Price Administration used opinion surveys to keep close to the public pulse, as did the War Production Board. Again, caution was used about too literal interpretation of the manifest content of single items, and effort was made to analyze the problem in detail with good statistical techniques.

A rather interesting illustration of the use of scientific techniques to ascertain opinion in a relatively unstructured situation was the work of the Research Branch of the Information and Education Division in the War Department in contributing to the development of the point system. The branch was asked to survey soldiers and propose a system which could be predicted to reduce to a minimum the expected complaints with respect to order of discharge, though of course nobody dreamed that all complaints could be eliminated. This study was initiated in the fall of 1943. Here *really* was an unstructured situation. If you asked a soldier back in those days who should get out of the Army early when the war was over, you would have found this was a subject he had not thought about except in terms of himself. Should older men get a preference? Sure. Should combat veterans? Of course. Should fathers? Naturally. And so on through the gamut of categories—except, perhaps, noncoms. The difficulty was that few thought it through far enough to see that if you gave men in X category a preference this would penalize category Y men relatively, even if Y men got some kind of a preference, too. Finally, it was decided to give the men a series of paired comparisons somewhat like the following: Here are two men, Brown and Jones. Both have been overseas two years and both are married. Who should get out first? Brown, who is twenty-five and has been through two campaigns? Or Jones, who is thirty-five but has not been in combat? If the respondent voted

for Brown he voted, in effect, for giving two campaigns preference over ten years of age.

The problem was to reconcile the information, not always consistent, from a series of such comparisons and to construct a series of weights which would, on reapplication to the original comparisons, most closely approximate the men's concrete choices. This involved devising some new mathematical formulations, which are described in a recent issue of the *Annals of Mathematical Statistics.* The point system announced, which was a fairly close practical approximation to what had been derived from an analysis of soldier responses, was initially acclaimed by the press with remarkable unanimity, as shown by an O.W.I. survey of editorial opinion; was approved as fair by about 70 percent of the public, according to a Gallup Poll (just about the same proportion, incidentally, as approved Selective Service); and was approved by about 70 percent of the soldiers. There were some expected howls from families of soldiers who had not been overseas because overseas men got too much credit compared with, say, fathers; and there were even stronger howls from overseas men because combat service was inadequately rewarded in their judgment as compared with, say, fathers. But by the time V–J Day came around two-thirds of the soldiers still approved the point system. As time went on the great anxiety of the soldiers to come home and of the home folks to have them back tended to bring the point system in for more criticism, as its sole function, namely, determining the *priority* of discharge, became confused with *speed* of discharge. But further studies showed that the majority of the soldiers still thought the point system was fair, even though there was mounting dissatisfaction with the speed of demobilization.

Some of those in research who were trying to keep their fingers on the GI pulse after V–E Day are convinced that a priority system which would have opened the gates to widespread favoritism or which would have struck the majority of soldiers as unjust or arbitrary—coming when the pressure for discharge was explosive—might have precipitated a most embarrassing situation for America. How much the recognized justice of the point system helped, we will never know, but I think that mathematical statisticians and social scientists can take satisfaction in the fact that their technical tools were called for and used on a problem of such compelling urgency. Incidentally, a rather nice tribute to the Army's point system was paid by the Marine Corps—which adopted the system without a change. When the Marine Corps imitates the Army, that's something!

These illustrations from research within the government could be multiplied many times from the work of both governmental and nongovernmental research organizations. They show the recognition which has already been given to the necessity of working out carefully the structure of opinion on a given issue, lest the conclusions be misleading. Some recent developments in scale analysis and in the use of an intensity function are particularly promising, though still in the developmental stage. Much work needs to be done on methodology before surveys become as reliable an instrument for measuring and predicting opinion as they someday will become. Much work also needs to be done in reexamining theories of public-opinion formation. Survey techniques will help to test these theories; better theories, in turn, will aid in the analysis of an issue and thus produce more useful survey techniques.

Finally, a few words should be said

about the danger that polls will have too much rather than too little influence on governmental action. I am here speaking about thoroughly good surveys because superficial surveys with sloppily worded questions would have too much influence if they had any influence at all. It is the theory of representative government that the public delegates to its representatives, and that the executive delegates to its experts, a vast amount of technical detail about which the public cannot be expected to have an informed opinion. This is obviously necessary. It is also necessary that government play both a leading and a restraining role with respect to the public. For opinion surveys to develop so much prestige that no official would dare take a stand in the interests of the long-run will of the people when this stand conflicts with the short-run will of the people would be dangerous in the extreme. That day is not yet here, though it may be closer than we think. However, if we have Lincoln's faith in the people, we must not only recognize that the public must be the ultimate judge of the wisdom of its servants, but we must also recognize the necessity of giving the public every opportunity to become an informed judge. Surveys in the years ahead will presumably concentrate less on reporting what the public's off-the-cuff vote is on such a subject as, say, the type of authority which should control atomic energy and more and more on an analysis of how adequately various segments of the public are informed with respect to all the alternatives and how people with different amounts of information or misinformation view the problem in different ways. This helps speedily to bring the facts out into the glare of daylight so that public discussion in the press and radio, the barber shop and the living room, will not be based on obfuscation and myths about what such and such elements of the public want, and so that the leaders of public opinion—on all sides of the issue—can know exactly where their arguments need to be directed if they are to win support.

The social scientists—psychologists, sociologists, economists, aided by mathematical statisticians—feel a certain pride in reporting how tools forged by social science have come to play a role in the affairs of life. I think we are under no illusions. Like the application of the work of a chemist, the applications of new methods of opinion research may have their dangers to society as well as their advantages. We as social scientists have the obligation to make the tools better and better, and we as citizens have the obligation in and out of government to see that these powerful instruments are wisely employed, providing scientific measures to supplement the time-honored contacts between the public and its government. There is no turning back.

These tools can and must be improved and directed to serve their greatest function, namely, informing government and informing the public how thoroughly and with what result various segments of the public have pursued a public issue in the light of alternative contingencies. And by thus helping to improve the channels of communication, social science is making one of its contributions, helping to see to it that government of the people, by the people, and for the people shall not perish from the earth.

SCIENCE AND THE SUPERNATURAL

By ARTHUR H. COMPTON

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THOSE whose thinking is disciplined by science, like all others, need a basis for the good life, for aspiration, for courage to do great deeds. They need a faith to live by. The hope of the world lies in those who have such faith and who use the methods of science to make their visions become real. Such visions and hope and faith are not a part of science. Physics, chemistry, and biology are not concerned with them. They are known by an individual only as he himself experiences them. Though stimulated by the outside world, they are not of it. They are beyond the nature that science knows. Of such is the true "supernatural" that gives meaning to life. This "supernatural" is as real as the natural world of science and is consistent with the most rigorous application of the scientific method.

The "supernatural" specifically denied by Anton Carlson in the August 1944 number of THE SCIENTIFIC MONTHLY is the supernatural of magic, especially events contrary to known natural processes. Carlson has done a real service to those concerned with finding adequate objectives for living in a scientific world by showing the danger that comes from basing our greatest values on evidence that science cannot accept. Science requires of religion that the language in which its great truths have been stated by prophets who lived in an age of magic, miracles, and mysticism be translated into a language of verifiable fact. This lesson our religious leaders must learn, or inevitably with the growth of public reliance on science the effectiveness of their teaching will decline.

Having, however, thus performed a truly Herculean task of cleaning the Augean stables, Carlson steals away with the cattle that the stables would shelter. He denies significance to anything other than physical events, that is, events observable by the senses or measurable by physical instruments. At least it is easy to read this implication into his statement, as is done by Anna Rosenberg (in the November 1944 number of the same journal) in her letter supporting his positivistic position. It is at this point at which probably most American scientists would emphatically part company with Carlson and the positivists.

Though Carlson's discussion shows clearly his interest in the good life, since he denies the supernatural it would be readily inferred that he considers religion as inconsistent with science and inimical to the good life. Whether or not such an inference would be fair to Carlson, it would give a false view of both science and religion.

Let me then give a scientist's view of the fundamentals of religion. The following ideas are taken almost wholly from religious sources whose traditional authenticity is unquestionable. Yet I find no way in which they conflict with the spirit of even Carlson's Spartan science.

I take it that religion is concerned with the worship of God. "God," however, is a word with many meanings. I shall consider three meanings that are of special religious significance: God as the ruler of the universe; God as a hero to be admired and emulated; and God as the spirit of the highest good which serves as the guiding principle of one's life.

Better than at any earlier time we who live in a scientific world can recognize the grandeur of the universe of which we are a part. We have learned many of the laws according to which it works, of the motions of stars and atoms, and something of the evolution of galaxies and of life. What will be our attitude toward this world? Shall we fear what may happen to us, be impassive, or have confidence in what the future will bring? Can our efforts adapt our world to our needs, or must we suppose that an irrevocable fate approaches over which we have no control, so that effort is meaningless?

Science tells us that a well-adapted organism thrives and an ill-adapted one declines and eventually disappears. This may be summarized by saying that on the whole the world is kind to all that live and is especially so to those that learn nature's laws and follow them. Experience shows that we can use the forces of nature to shape our world and that our lives are better or worse according to what type of changes we make.

Jesus has summarized such common experience with the great powers that shape our destinies by the phrase "our Father which art in heaven," or "heavenly Father." By this he implies that these great powers help those who work in accord with their laws. As children in our father's home, we have a proper place in the world. We also can share in shaping the world: "My Father worketh to this end, and I work."

It is helpful to compare such a religious concept with a typical scientific theory; for example, the physicist's theory of the ether. When we pray to our fatherly God it is common experience that we receive courage and strength to do deeds of friendliness toward his children. It is hard to think of receiving strength without imagining a being which gives us the strength. Similarly, by performing certain optical experiments, we find that light has the properties of waves, and it is hard to think of waves without imagining a medium in which the waves can occur. Hence the concept of the "luminiferous ether."

Both the fatherly God and the luminiferous ether are hypotheses which are fruitful of useful consequences. If God is our father, we are his children and other persons become our brothers. We thus have an understandable basis for loving our fellows. When we examine the properties that the ether must have to transmit waves with the speed of light, we find that these properties also fit it to transmit electric and magnetic forces and we have a basis for understanding the relation between electricity and light. If the Ruler of the Universe is as a Father, we can rest assured that he will provide for our basic needs. If space is filled with a medium that has the properties needed for it to transmit electrical waves of light, then we can predict interesting effects produced on light by electrical and magnetic fields, predictions which when tested by Faraday and Kerr are found to be correct.

A scientist gauges the value of a theory by the fruitfulness of its consequences. In judging the worth of religious teachings our highest authority says, "By their fruits ye shall know them." By this test both the theory of the ether and the concept of God as a Father are fruitful of valuable results and hence good.

The rationalist can correctly claim that in neither case do the tests supply valid evidence for the truth of the hypothesis. Is it God that gives us strength or is it our faith that there is a God? Is there indeed a medium that transmits the waves, or is the medium merely an intellectual device for interpreting an observed pattern of optical effects? Physicists recognize that the

"ether" is a convenient name for certain properties of space and that calling it a "medium" gives inaccurate connotations because of our familiarity with solid, liquid, and gaseous media; yet because in terms of this etherial medium it is possible to explain what actually happens, we continue to use the concept. An "etherial medium" is the best brief description of these properties of space that has been invented. It helps our constructive imagination to think of an "ether" in dealing with light and electricity. Similarly, theologians recognize that the use of the term "God" is only a convenient name for certain great powers that operate in nature and particularly in man and that speaking of God as a "father" gives inaccurate connotations because of our tendency to think of all the physiological characteristics of the human fathers that we know. Yet because in terms of this fatherly God we can so accurately describe what actually happens in the normal life of an individual living in a world to which he is adapted, the concept remains very useful and no other brief description of these powers has proved to be so adequate. Thinking of a "fatherly God" thus helps in giving us a correct attitude toward our world.

"Is there a fatherly God?" is a question precisely similar to "Is there an etherial medium?" In both cases the answer is Yes and No. If by "etherial" you mean something mystical or to be found only outside the earth, if by "medium" you mean a solid or a liquid or a gas, there is no "etherial medium" that transmits waves of light. But if by "etherial" you mean the dielectric constant and magnetic permeability appropriate to empty space and if by "medium" you mean that which transmits electromagnetic waves, there is in truth an etherial medium.

Likewise, if by "father" you mean the physiological sire of a child, if by "God" you means a manlike entity that dwells in the space between the stars, there is no "fatherly God." But if by "fatherly" you refer to the friendly, yet disciplinary, aspects of the world that teach you how best to act to meet whatever happens and to be pleased that your experiences make you more of a man, if by "God" you mean the creative and controlling forces at work in the world, then there is indeed a "fatherly God" for all who want to find him.

So MUCH for the concept of God as Ruler of the Universe. Now let us think of God as a hero to be admired and emulated. Our heroes have always been our "gods" who have helped us in shaping our attitudes and actions. We see in our great men the embodiment of some spirit we admire and want to share. I remember how my father reasoned out his own Christian philosophy and used it to fortify and stabilize his life and, trying to follow his footsteps, I become an ancestor worshiper. I have an older brother whose interest and achievement in science have inspired me to do likewise and I have sought and carefully weighed his counsel when facing crucial decisions. The General with whom I was most intimately associated in the effort to win the war has become to me the personification of complete patriotism. He helps me understand the values and the dangers of that great virtue. Anton Carlson I admire because of his devotion to rigorous scientific truth. "Honest Anton," we call him and love him for his courage, though we may deplore his inability to recognize the limitations of science. From earliest childhood I have learned to see in Jesus the supreme example of one who loves his neighbors and expresses that love in actions that count, who knows that people can find their souls by losing themselves in something of great value, who will die rather than deny the truth in favor of

the popular view held by his most respected contemporaries. That Jesus' spirit lives so vitally in men today makes me hope that by following in his footsteps in my small way I also may live forever.

It would do violence to common usage to say, except in the extreme case of the one whom I hold as my supreme example, that these men are my "gods." But it is correct to say that for me they all represent certain aspects of the Divine Spirit, and by knowing them I come to know my God. In particular, Jesus becomes the central figure in exemplifying the ideals that I would like to live by. I admire him, emulate him, and become loyal to him. He becomes my Hero-God.

YET from the religious point of view, the most fundamental meaning of "God" is neither the Ruler of the Universe nor the Hero after whom one patterns his life. It is rather the "highest good" which one takes as the guiding principle of his life.

I am reminded of the day when Jesus paused to chat with the woman at the well. You recall the setting. "Our fathers worshiped in this mountain," was the woman's comment. "And ye say that in Jerusalem is the place where men ought to worship." "Believe me," replied Jesus, "the hour cometh, and now is, when the true worshipers shall worship the Father in spirit and in truth. God is a spirit; and they that worship him must worship him in spirit and in truth."

If God is what we worship, God is that which we value most highly, to which we would devote our lives. We may worship that God by prayer or by action. Prayer consists in trying to find what our God would have us do. The action is determined on the basis of the answer to that prayer.

Take for example the man whose God is money. The gaining of riches becomes the objective of his life. His sordid prayer becomes the scheming as to how to gain more wealth, and his acquisitiveness is reflected in his every act. Or take the man whose God is the State. He puts its welfare above all other values. He is the patriot who sees the supreme good in the glory of his nation, even at the expense of the rest of the world. The Christian's God is the God of love. "God is love and he whoever continues in love keeps in union with Him and he with God." Perhaps one should explain that by Christian love is meant not a physical passion nor a sentiment of adoration and admiration, but a friendliness that expresses itself in doing good to one's neighbors. Prayer to the God of love means a thoughtful consideration as to how such good can best be done. The action resulting from such a prayer is the highest worship of the God of love. "A religious observance that is pure and stainless in the sight of God the Father is this: to look after orphans and widows in their trouble, and keep one's self unstained by the world."

Jesus is vehement in his insistence that concern with the true worth of things is the one essential without which life really has no value: "Whoever speaks against the Son of Man will be forgiven for it, but whoever speaks against the Holy Spirit cannot be forgiven for it, either in this world or in the world to come." St. Paul in a positive way is equally outspoken: "The spiritual man is alive to all true values, but his own true value no unspiritual man can see."

There is an immense difference between a good religion and a bad religion in the satisfactions and disappointments to which they lead. The main difference is the nature of the values or the kind of spirit that the religion inspires. The true God is the spirit which is found to

be of lasting value, so that when the test comes one can feel that whatever may happen he has spent his life for the best that he knows. The false God is the desire which when attained does not bring satisfaction but makes one feel that he has betrayed or lost something of greater value.

Here is the essence of religion, the pearl of great price for which one sells everything that he has in order that he may own the pearl. One's God is in truth the spirit that inspires his actions —that which gives him the aspiration and purpose—the will to lose himself in something of value. What is that spirit? The Christian answer is, love which shows itself in deeds that help one's fellows.

It remains only to point out that the God of the "highest good" is indeed effective in our lives. As during the recent war we saw the value of freedom, our nation became inspired to the great achievement that brought us victory. Freedom was the great good, the aspect of God, that we sought. I saw one group, determined to stop the Nazi threat against the world's freedom, catch the vision of the new weapon of atomic energy. With faith in that vision and driven by devotion to freedom, they performed the miracle of the atomic bomb. I have seen my friends, worshiping the God of love, catch the vision of a richer life for all mankind and by heroic self-sacrifice bring new hope to people whose lives had held little meaning. I have seen young men and women in college catch the spirit of service for their fellows and do a job far greater than that of their companions who had failed to catch that spirit. And the lives of the latter have been drab, whereas those that have been driven by the spirit of service have had the glowing faces that come with the rich life that money cannot buy. Do we want magic and mysticism, an Aladdin's lamp that will change a peasant's hut into a prince's palace? Here in worship of the God of the spirit of the highest good such magic is truly to be found.

WITHOUT saying so, I have outlined here an interpretation of that most abstruse of Christian teachings, the doctrine of the Trinity: God the Father, God the Hero-Son, and God the Spirit. I doubt if even Professor Carlson would take exception to my presentation. For in their essence there can be no conflict between science and religion. Science is a reliable method of finding truth. Religion is the search for a satisfying basis for life.

Every religion builds for itself a structure which goes far beyond the foundation that I have just sketched. It develops its guiding principles using the best thought of the time. Jesus taught in stories of daily life. The later Christian writings were shaped in the combined atmosphere of later Greek philosophy and of oriental magic and mysticism. It was an intellectual atmosphere to which present-day thought is ill adapted. It is of most vital importance that the eternal spirit of religion for which our century cries shall break out of the sarcophagus of the magic formulas in which it is buried and come to vigorous life in our lives.

The breaking of idols is a necessary recurring process. This is done not only in religion. Science also has its Gideons, its John the Baptists, and its Luthers. It was not long ago that Heisenberg told the scientific world,

> The resolution of the paradoxes of atomic physics can be accomplished only by renunciation of old and cherished ideas. Most important of these is the idea that natural phenomena obey exact laws—the principle of causality.

No principle had seemed more precious in science than that of exact laws, and it has gone hard with many old heroes in the field to see the younger men quit the

faith that to them seemed the very foundation of their thinking. Yet the worshipers of this idol are rapidly growing less, and in its place is a spirit of faith in the simplest interpretation of scientific evidence which has given to physics a vigorous new life.

Carlson is concerned with the concepts which for many centuries have served as focusing points for the thought and meditation of millions of faithful religious souls. These concepts have served as our icons and idols; but some of them are now as anachronistic as the golden calf. If our religious leaders are to bring to the present day the vital, living spirit of their faith, they must take Carlson seriously. Science is growing. Yet a world that has science needs as never before the inspiration that religion has to offer. In a strict, literal sense, Carlson is right, that magic and miracles and mysticism are of an outlived era. But the other half of the picture is far more important. Beyond the nature taught by science is the spirit that gives meaning to life.

"So faith, hope and love endure. These are the great three, and the greatest of them is love." This is not science, or nature. It is the true supernatural.

A YULETIDE PRAYER

1945

Prometheus, friend of man, brought heavenly fire,
To kindle hearth and beacon, forge and pyre.
Many his gift for evil uses take—
For war and arson, burnings at the stake.

Revealing Science now the key has gained
To loose primordial force in atoms chained,
Tremendous power, the heartbeat of the world—
Or else destruction's bomb on humans hurled.

Lord, grant that peoples and their leaders see
The greatest good for all humanity,
And use what Science brings into our ken
To hasten peace on earth, good will towards men.

JEROME ALEXANDER

THE HUMMINGBIRDS' BROOK

By ALEXANDER F. SKUTCH
SAN ISIDRO DEL GENERAL, COSTA RICA

When I planted a hedge about my yard, I chose the purple-flowered *Stachytarpheta,* a kind of bushy verbena, not because it forms the primmest of hedges but because of all the hedge shrubs I know it is the most attractive to hummingbirds. The little, short-tubed blossoms form a compact wreath about the middle of the long, naked flower spike, moving upward as the withelike spike continues to grow. If the early part of the year is not too dry, the plant blooms throughout the twelve months and provides a never-failing source of nectar for the flower sprites.

First to discover the earliest blossoms of my newly-planted hedge, and ever since their best patron, was Guimet's Hummingbird, a tiny emerald gem whose head, turned toward the watcher, flashes forth most intense metallic violet. A white spot behind each eye gives him an alert, wide-awake aspect, entirely in keeping with his swift, dashing movements. Suspended between wings vibrating so rapidly as to be invisible, he makes the circuit of the wreath of florets, the tip of his slender black bill probing the heart of each for a single instant, then darts off to a neighboring spike. These glittering bits of animation carry my thoughts back to the Hummingbirds' Brook.

It was hard to stay inside the thick walls of the old museum in San José during those clear, sunny months that started off the year. All around me in the herbarium were cases full of botanical specimens, long since dry and colorless, for which I had recently become responsible. They clamored, as well as such lifeless things may, for care and rearrangement. But the weather of the early *verano,* with its cold, starry nights and warm, sun-flooded days, was like some heady wine. Try as I might, I could not imprison my thoughts within those massive walls of puddled clay, among the herbarium specimens. They persisted in floating out over the surrounding mountains whence, years before, Pittier and Tonduz and Brenes had gathered those same specimens. Through the deep-embrasured windows of the herbarium I could see nothing of those hills, but only a little sunlit rectangle of courtyard where goldfish swam in a pond and a few orchids grew. But climbing the dusty, circling stairway of the old square tower at the end of the building, I could fill my eyes with the sight of the green hills that swept in a wide circle about the narrow plateau where the city stood, calling a naturalist in so many directions at once that his mind became a disordered whirl of enticing and impracticable projects for exploration. In the northeast, seeming very close in the clear morning atmosphere, rose the immense, sprawling bulk of the Volcano Irazú, with a lofty column of smoke arising from its flat summit. Blown southward by the trade wind, this eruptive material spread a fine layer of dust over the glass cases of the museum.

The call of those green hills was too strong to be resisted, especially by one who had so recently forsworn his full liberty to roam them. Many a plant still unknown to science lurked among those forested mountains, so inviting in the distance, but upon actual contact so rugged and forbidding and opposing such formidable obstacles to the progress of puny man. Would it not be well to collect, now in the good weather, samples

of the flora of some hitherto unexplored nook among the mountains? A few thousand new specimens, more or less, to arrange along with the old ones during the long, wet months that would follow could make no great difference. The sympathetic director of the museum readily agreed with these arguments. I was free to take to the hills!

A friend in the southern part of the country wrote that he had found a little house for me in the valley of the Río Pacuar, on a farm adjoining his own. My horse was waiting in his pasture; Efraim, the boy who in past years had cooked for me and carried the plant press, was again willing to serve. The Ministry of Education provided an airplane pass. Leaving the capital before sunrise, the trimotored machine set me down in the village of San Isidro del General in time for breakfast. In little more than half an hour we had passed over a wilderness of forest and mountain which, without wings, we could not have traversed in less than four days of toilsome journeying over rough trails. That same afternoon, my friend Don Juan and I set forth on foot to visit his farm at Santa Rosa and the cabin he had rented for my use. We went slowly, for those afternoons of late February were warm and the road dry and dusty. We were ashamed to count how many times we paused to rest and chat with farmers while we refreshed ourselves with the sweet golden oranges that grew by the roadside. The narrow, winding cartway rose and fell, crossing many a ridge and many a clear stream in the valleys, passing among hillside pastures, strips of forest, and fields where the dry stalks of last year's maize were already all but hidden among the swiftly springing weeds.

At length, as the sun fell lower, we came to the brow of a slope longer than any we had left behind. Far below, the tree-bordered channel of the Pacuar meandered through verdant, shady pastures, amid which stood, here and there, low, rough farmhouses roofed with dull-red tiles. Beyond the valley the coastal range rose up, summit behind summit, all clad in a dark green mantle of forest. The steep hills were notched by wooded gorges, whose cool, shadowed depths stood out in dark contrast to the intervening ridges aglow in the sunshine. In the north rose the rounded bosses of El Cerro de la Muerte, huge and grim and gray, and the other lofty summits of the Talamancan Cordillera. What a scene it made!—the deep, narrow valley with its quiet dwellings set in the bright green of pastures and cultivation like "a haunt of ancient peace" in the midst of those wild hills.

Near the foot of the long slope we entered Don Juan's pasture, caught and saddled our horses, and resumed our journey on four feet instead of two. By a broad, shallow ford we rode across the Pacuar, passed over a level pasture, then forded the rocky bed of the Río San Antonio. On a shelf cut into the steep hillside above this stream stood the house I was to occupy. It was of the usual type and soon inspected: a narrow porch across the front; opening onto this, two small, square rooms to serve as living room and kitchen; two tiny, rectangular cubicles under the sloping roof at the rear to be used as bedrooms. In the kitchen were some shelves and a wooden platform covered with clay upon which to make a fire, the smoke escaping as best it might; in one of the bedrooms, a wooden bedstead with hard boards instead of springs; in the *sala,* or living room, a rickety table, a pair of stools without backs, and a great heap of maize ears piled up in a corner. The roof was of unglazed tiles, the walls of rough, unpainted boards, partly papered over on the interior with old newspapers boldly announcing patented remedies for the most intimate maladies.

Not a palatial nor even a homelike dwelling, certainly; but with a few cooking utensils and a folding canvas cot—enough, with the collecting apparatus and some staple supplies, to fill an ox-cart—it would make an exceptionally comfortable camp. If there were no pictures save the cartoons in the yellowing newspapers to relieve the drabness of the walls, it was only necessary to throw open the wooden shutters that closed the glassless windows to enjoy a diorama painted with master strokes on the grandest scale. In the foreground spread level pastures, shaded by slender, stately *ojoche* trees nearly fifty yards high. In the midst of the meadows, two lines of lower trees, converging into one line at the right, indicated the point of confluence of the Pacuar and San Antonio rivers. Beyond, the mountains rose up, crest above forested crest, to the bare, treeless summit of El Cerro de la Muerte; and the long ridges of the continental divide, with their ever-changing masses of cloud, closed off the prospect to the north.

Locking up the vacant cottage, we mounted our horses to ride up the ridge that rose sharply behind it. A hundred yards from the dwelling the forest began like a wall, forty yards high. As we neared its edge, a small bird with spotless white plumage flew out from a treetop and swung in a long catenary curve across the valley to the hanging forest on the farther side. It was my first Antonia's Snowy Cotinga (*Carpodectes nitidus antoniae*). I looked upon it as an augury for a prosperous season.

Two days later we moved into our little cabin. Efraim made up the fire and put the beans and rice on to boil; Bayon grazed contentedly in the pasture at the side; I unpacked and set up the apparatus for drying the botanical specimens. In a day or so we had settled down to a routine. Arising at daybreak, we breakfasted as the sun's first rays struck up the valley, dissolving the silvery mists that had gathered during the night. Almost every morning at sunrise, a flock of Little Blue Herons (*Florida caerulea*), four adults in slate-blue plumage and eleven young birds clad in purest white, winged deliberately up the river, following every winding of the tree-shaded channel and holding our gaze enthralled until they vanished around a curve. At sunset they returned down the valley. Later I found where they roosted, on leafy boughs overhanging the channel.

While the sun was still low above the crests of the forest, we locked up the cabin and set forth on the day's excursion, with lunch in the knapsack and the plant press full of papers for the specimens. No matter where a man lives, he soon finds a favorite walk which attracts him beyond all others and of which he never tires. So it was with us. There were few roads or even clean paths in the immediate neighborhood, but the course of the Río San Antonio became our highway. We drank from and bathed in its waters, and it led us back among the hills into haunts of unsuspected beauty. It was an enchanting stream. Its current, filtered through scarcely broken forests, was always clear. Even when swollen with the heavy rains of May and June, it never became brown and turbid like the Pacuar, which flowed through a cleared and cultivated valley and when in flood formed a sharp contrast with the limpid tributary stream. During the nearly rainless months of February and March both rivers were low and gentle, and the smaller San Antonio could at many points be crossed dry-shod on steppingstones.

First we explored the lower portion of the stream, where it flowed through the pastures. Here and there it slipped over a rock to form a low, murmurous cascade, but there were no falls of any great height. The channel was shaded by

trees, chiefly the gnarled *sotecaballo,* or riverwood (*Pithecolobium*), whose long boughs reached far over the channel and in places completely overarched it, forming a dark, cool retreat never penetrated by the hot midday sun. Verdant masses of the river *Cuphea,* a shrubby relative of the humble clammy herb of northern fields, covered the rocks that rose above the water; and on the portions of these rocks recently left dry by the falling current, innumerable tiny brown seed pods of the Podostemonaceae, no bigger than the moss capsules for which they are sometimes mistaken, stood up on their short, threadlike brown stalks. Feathery green fronds of the same delicate water herbs—which include some of the very smallest of all flowering plants—waved in the flowing water where they grew attached to portions of the rocks still submerged. At the end of February a climber of the bignonia family spread a profusion of pretty pink trumpet blossoms over the lower branches of the riverside trees; and later another woody vine (*Securidaca*), an aspiring relative of the little northern milkwort, displayed in the treetops dense masses of small, two-winged, pealike blossoms, forming delightful expanses of pinkish-lavender color.

Where the twisted riverwood trees cast the deepest shade over the water and were most heavily burdened with an aerial garden of orchids, ferns, bromeliads, and other air plants (displaying here in the open air a collection of conservatory plants which for the variety and magnificence of its specimens would make any northern florist turn green with envy) a slender log formed a footbridge from shore to shore. The slippery upper face of the log had been only slightly flattened with the axe, and one wearing shoes found it prudent to support himself with a long pole as he passed over. Beneath this rustic bridge, the current, which just above had passed turbulently along a boulder-strewn reach of the channel, flowed smooth and deep over great, dark, flat rock strata of gentle inclination, locally called *lajas.* Later, when the flood waters carried the log away, we could scarcely leave our secluded camp save by fording the swollen current on horseback or else making a long and difficult detour down the river.

Above the still waters by the footbridge, a Royal Flycatcher (*Onychorhynchus mexicanus*) hung her yard-long nest of brown fibers; here where no boisterous wind could roll the two brown eggs from the shallow niche in the middle of the tangled mass that so little resembled a bird's nest. Only on the rarest and most memorable of occasions did she or her mate spread fanwise their high, scarlet diadems, which transformed a pair of dull, olive-colored birds with low topknots into superb creatures of regal distinction. Here, too, lived a pair of Buff-rumped Warblers (*Basileuterus fulvicauda*), perpetually wagging their dark-tipped, pale yellow tails as they foraged along the shore and over the rocks in the channel. The male sang a ringing crescendo, loud, mellow, and jubilant; and from time to time his mate replied in a full-toned warble so beautiful that, no less than the music of Orpheus, it seemed to possess the power to "draw iron tears down Pluto's cheek." In April this happy pair, working side by side to the accompaniment of their flowing song, built their domed nest upon a fern-shaded rock on the bank of the stream; but some creature broke up the nest before the two spotted eggs could hatch.

One morning in April, as we crossed the footbridge, a small animal clambered up the underside of the thick trunk of a great riverwood tree. Climbing back-downward along the inclined trunk until it reached some erect branches, it easily scrambled up among the foliage, where it stopped in full view. It was a kinka-

jou (*Potos flavus*), a relative of the raccoon and the coatimundi, about the size of the former but more slender and shorter-legged, and everywhere, including its long, gracefully curving tail, clothed with brownish-gray fur that appeared very thick and soft. Despite the low, flattened crown, its little face was attractive and appealing, with its short, blunt, black muzzle, large dark eyes, and little ears set far down on the sides of the head and expressively mobile. I have sometimes seen that puckish, somnolent face thrust sleepily from the doorway of a hole made by one of the large woodpeckers, or out of a small natural cavity, in a trunk where my taps had aroused the beastie from its day-long slumbers.

But this particular kinkajou preferred on a warm afternoon to take its siesta among the open boughs. Disregarding two human spectators, the animal settled itself comfortably among the branches and began to wash its fur with its tongue, which was remarkably long and slender. It seemed very sleepy, for it frequently interrupted its licking to yawn, extruding its pink tongue to an amazing length. It continued alternately to yawn and lazily lick its pelage until we grew tired of watching. Returning at intervals through the afternoon, I found the kinkajou slumbering in various comfortable positions, once resting back downward in a crotch, its head bent forward and resting on its abdomen, its arms thrown over the neighboring branches for support, its feet in the air. When aroused, it yawned with sleepy indifference and promptly resumed its slumbers.

An hour after nightfall, when day had dawned for it, I found the kinkajou moving away among the uppermost boughs of the riverwood tree, doubtless to breakfast upon the fruits of neighboring trees. Its eyes shone with intense brilliance in the beam of my electric torch. I wish that I could have followed as it moved off through the dusky foliage, to learn more of its ways. What a pity that so many of our fellow-mammals are children of the night, going about the business of living under the cover of darkness and remaining stranger to us than the birds, which are not so close of kin. Even the crepuscular Pauraque (*Nyctidromus albicollis*) that drowsed all day beneath the thicket at the edge of the pasture, venturing forth in the twilight to sound its clear, plaintive cries, was more companionable than most of the wild four-footed animals among which we dwelt.

From the pastures we gradually extended our explorations along the upper reaches of the river. The number of specimens to be gathered made it impossible to cover a great distance on any single day; but each day we penetrated a little farther into the mountain fastnesses. Now we were no longer able to walk easily over the meadows by the riverside and found it simplest to make our way along the bed of the stream itself, stepping or jumping laboriously from rock to rock or from ledge to ledge, often crossing from one side to the other to take advantage of the rocks closest together. But sometimes, where deep pools extended from shore to shore, we were obliged to leave the channel and with our long machetes cut a path through the undergrowth at the forest's edge.

At most points the slopes rose up steeply from the brink of the stream. They were covered with lofty forest trees that met above the narrowing channel and cast a deep shade over its waters. In February, a tall shrub of the acanthus family, a species of *Aphelandra*, displayed glowing masses of scarlet blossoms in the rather open glades along the river. But aside from this attractive shrub, which soon passed from bloom, there was, as usual, scarcely any color in the undergrowth of the forest. The

course of the stream itself was slightly more colorful. At times during the brighter hours of the day, a wide-winged Morpho butterfly traced its swift, erratic course above the channel, flashing glints of the most intense azure. Other brilliant butterflies were not absent; and there were gigantic dragonflies whose long wings were of glassy transparency and colorless save for a small rectangle of deep blue at the tip of each. Over the rocks in and beside the river and on the foliage along the banks rested bright-colored little frogs, seldom much over an inch in length, boldly marked with black and green and—on the larger specimens—red. These were sluggish creatures and, unlike the majority of batrachians, exceedingly reluctant to remove themselves from beneath human feet. At best they would creep slowly out of our way, so that often they owed their lives more to our own care in placing our steps than to any praiseworthy efforts of their own. We forbore to touch these showy frogs, for they are said to be poisonous. Their excessive abundance and their indifference to concealment, in a region where even inconspicuous green and brown frogs are careful to hide themselves from the many frog-eating birds and reptiles, made me confident that we had here a genuine example of warning coloration.

The rocks along the stream were overgrown with delicate ferns of great beauty. A low herb with modest white flowers (*Spigelia humboldtiana*) blossomed on ledges where a little soil had accumulated. Great boulders whose tops stood well above the water level supported profuse overgrowths of plants, including a tall, glossy-leafed begonia with white flowers and clusias with fleshy foliage and fragrant white blossoms. On an islet we found a splendid shrubby *Columnea,* whose long, furry leaves, red over most of the lower surface, were spread out fanwise and completely sheltered the slender, tubular, red corollas. I had never before seen this beautiful plant; nor, apparently, had any other botanist, for in Washington it was declared to be of a species new to science.

During most of the day a profound silence reigned along this forest waterway; the only habitual sounds were the soft murmur of the falling waters and the loud buzzing of the great cicadas among the trees. These noises were so continuously in our ears that we soon lost consciousness of them; they formed the background against which less constant sounds stood out. Among these were the loud, sweet songs of the Buff-rumped Warblers or, more rarely, the clear, ringing notes of the bay-backed River Wren, which dwelt here where the stream flowed through the forest as well as along the bushy margins of its course through the clearings. Now and again the short, compelling whistles of the Wood Wren rang out of the forest. Seldom, indeed, at this season, did we hear the voice of some other bird such as the exquisitely modulated whistles of the Chestnut-headed Tinamou. But on the morning when we frightened a pair of Crested Guans passing with half-grown young through the treetops, we had no lack of loud, excited calls, high-pitched and weak for such big, long-tailed fowl, the size of a hen turkey.

Continuing up the main stream, we reached a portion of the channel which was, if possible, still more beautiful than that we already knew. The river here followed the dip of the strata of the massive dark gray rock of which those hills were so largely built; but its descent was more gradual than the inclination of the rock layers. Thus each stratum exposed its edge to the erosive action of the stream. The soft layers had been worn away, leaving pools held back by the hard layers. Some of these pools were wide and deep, each brimful of the clearest water, which slipped over the lip to flow down a long, even incline to

another pool below. In places there were abrupt falls, but there were also long reaches of nearly level channel, strewn with great, irregular rocks. Here and there low cliffs, draped with verdure, rose from the water's edge. Everywhere the great trees of the forest stood along both banks and cast their shade over the hurrying, dancing waters. In the inmost recesses of this mountain forest the world and its bustling activity seemed infinitely remote; yet at times even here our thoughts were abruptly recalled to it by the hum of an airplane passing unseen above the treetops on its way from San Isidro to one of the little coastal towns.

As we laboriously worked our way up the rough, difficult watercourse, Efraim espied on the rocks ahead a bird such as neither of us had ever beheld. It was a fairly big, stout-bodied fowl, with long legs, long slender neck, and a sharp, straight bill of moderate length. In form it somewhat resembled a heron or bittern, but in coloration it was quite different from members of these families, and its relatively much longer tail set it apart from them at a glance. Its colors were rather subdued: black on the head, brown on the neck, maroon-brown on the breast, dark gray on the back and closed wings, white on the throat and abdomen, and nearly everywhere barred, spotted, or streaked with black and white. Its eyes were deep red, and its long legs, naked to well above the knee joint, bright orange.

Such was the appearance of the strange bird as it walked deliberately over the steeply inclined rock face between two pools, plucking certain small objects from the rocks washed by the smoothly-flowing rapids. We had watched it for many minutes, attracted by its rareness rather than its beauty, when it slipped on the smooth wet rock and, half-opening its wings to balance itself, dazzled us with a glimpse of unsuspected splendor. As it flitted from boulder to boulder, it continued to reveal tantalizing flashes of hidden beauty. But only when the bird spread its wings broadly for a longer flight did it display their full magnificence. On each was a big, round shield of deep orange-chestnut, set in the midst of an area of much paler orange-buff—a sun darkly glowing in a sunset-tinted sky. There was also a second patch of orange-chestnut near the tip of each wing. When I saw those lovely wings painted with the image of the sun, I had no doubt that I had my first Sun-Bittern (*Eurypyga helias*) before me. Like that other denizen of these forest waterways, the Royal Flycatcher, this rare bird kept its proudest ornament concealed most of the time.

The most important affluent of the Río San Antonio from the right was a rocky streamlet hemmed in by steep, forested slopes, so narrow that at many points we could leap from bank to bank. But it also had its picturesque cascades and shared the wild beauty of the river to which it delivered up its unsullied waters. Along this narrow watercourse we discovered more birds' nests than along the broader stream. Here, in the still air, attached to the long, dangling, cordlike roots of epiphytic plants or to slender pendent vines and shoots of climbing bamboo, hung the exquisite nests of the little olive-green flycatcher called Pipromorpha. Each nest was a pear-shaped structure a foot in length, covered with green moss; a small round doorway in the side led into a cozy chamber well padded with vegetable fibers. In an even more conspicuous position above the channel, the Myiobius, a brisk little forest flycatcher with a bright yellow rump, had constructed her nest, a thin-walled pocket of brown fibers, with a visor-like projection shielding the round doorway in the side.

Most abundant along the watercourse, although also most difficult to detect,

were the nests of the Guimet's Hummingbirds (*Klais guimeti*), each a tiny chalice of green moss, softly lined with seed down of a light buffy color and fastened by spider's silk to slender, usually drooping, leafy branches overhanging the channel, at heights of from three to twelve feet above the water. Without making a thorough search, we found three of these nests along the Río San Antonio and five along the smaller affluent, making eight occupied nests along two or three miles of waterway. There were perhaps as many more empty ones, of which we kept no accurate count. Early March is the height of the breeding season, and the nests might contain anything from two minute, elongate white eggs newly laid to feathered nestlings almost ready to fly. But there were never more than two eggs or nestlings in a nest. Because it is so unusual to find hummingbirds' nests in such abundance in the lowland forest (I have rarely seen more than three or four in a year) we decided to name the stream above which they hung *La Quebrada de los Gorriónes,* "The Hummingbirds' Brook."

After several hours of leisurely progress along the rocky bed of the brook, we halted for lunch in a spot of rare beauty. A steeply sloping ramp of naked gray rock rose in the stream bed before us between low, vertical cliffs. Down this incline the shrunken current of March flowed in two separate streams, one against the right base of the cliff in a long, even trough; the other, with a low waterfall in its course, made a broken and precipitous descent on the left. At the foot of the twin cataracts, the waters were reunited in a broad pool, nearly square in outline, about forty feet on a side, and deep enough to swim in. But only a naiad could have entered its pellucid depths without seeming to defile them. We left them in their unruffled serenity, to mirror the broad, infinitely subdivided fronds of a cluster of tree ferns that grew at the brink, surrounded by exuberant verdure and deeply shaded by the giants of the forest.

Climbing the tongue of rock between the cataracts, we found two more nests of the hummingbird, only forty feet apart. One, in a bush leaning over the falling water halfway up, held two eggs; the second, on a moss-covered pendulous branch of a small tree at the head of the waterfall, cradled two feathered nestlings. It was surprising to find these two occupied nests of the same species of hummingbird so close together; but as we continued along the course of the brook above the cataracts, we made a discovery still more astonishing. A richly branched bush, leaning far out over the narrow channel, almost blocked our way. As we pushed past, we espied another nest of the same kind, attached to a slender pendent branch, only three feet and three inches—almost exactly one meter—above the water. This nest was unusually tall, as though it had been built atop an older one—as hummingbirds' nests sometimes are—and it held two eggs. Four feet away in the same bush and fifteen inches higher above the water, was yet another nest, from which a well-feathered fledgling took flight as we approached. After a short pursuit, I captured the young fugitive and returned it beside its nestmate, where rather unexpectedly it was good enough to remain.

HUMMINGBIRDS are generally held to be unsociable. Certainly they lack the true convivial spirit that inspires such flocking birds as crows, grackles, and cormorants; and except in their courtship assemblies, where they exhibit a certain degree of community enterprise even in rivalry, it is every hummer for himself. Even male and female form no lasting attachments, and the latter always attends her nest and nestlings

quite alone. Hence the discovery of two hummingbird's nests in the same small bush was a memorable event, calling for further study. But the day was already far spent; and since it would be folly to try to move along that broken stream bed in the black dark that would prevail an hour after sunset, we were obliged to hurry downward before daylight forsook us.

Next morning I laboriously retraced my steps along the stream. I had already proved at other nests that if I sat quietly on a rock at no great distance, the hummingbirds would soon return to attend their eggs or nestlings. I seated myself on a rounded boulder, from which I commanded a good view of the two nests. The well-feathered nestlings in the one nearer me were bright, alert little sprites, who frequently preened their plumage and from time to time beat their wings into a haze, the while anchoring themselves to the bottom of the nest with their feet lest they be carried away by these vigorous exercises. When an adult of their kind came within sight, they were all alertness, uttering clear little droplets of sound in anticipation of good things to eat. Apparently they were unable to distinguish their mother from her neighbor, for they called in the same fashion at the approach of either. But the incubating hummer, each time she arrived, went directly to sit upon her own eggs, paying no attention to the other's family. The two fledglings had the gray throat of their mother rather than the deep violet of the adult male, as did all others of their age that we found.

The owners of these two nests, upon returning from an excursion into the forest, would sometimes approach me closely, hovering only a yard or two from my face while they subjected me to close scrutiny. Then, apparently satisfied that this strange monster that spied upon them was not to be dreaded, they went to their nests. Or, again, after feeding her nestlings, the mother of the two would approach to look me over once more before darting off. At a nest farther downstream, a hummingbird flew up to feed her babies, apparently without having noticed that during her absence I had seated myself near by. While she was in the midst of regurgitating food to them, my sudden movement in raising the binoculars for a closer view attracted her attention. At once interrupting the nestlings' meal, she darted up to examine her visitor in the usual fashion. Then she returned to plunge her sharp bill far down into a nestling's throat and continue the process of feeding, making me feel that I had created a favorable impression and my presence was not distasteful to her. These and many other examinations to which I have been subjected by hummingbirds of varied kinds appeared to be deliberate and purposeful acts, prompted in some instances by simple curiosity and in others by concern for the safety of their nests and offspring. They suggest that hummingbirds may be somewhat nearsighted, which is not surprising when one considers the minute size of the nests they build and of the insects they pluck from the vegetation or snatch from the air.

On approaching her nest, each hummingbird would alternately dart and hover, shooting a short distance now to this side and now to that, irregularly back and forth, at the end of each abrupt shift of position hanging stationary for an instant, on swiftly beating wings. Then of a sudden the tiny bird would plop down upon her eggs with her wings already folded against her sides, or alight upon the rim of the little cup to thrust her slender black bill far down into the crop of a fledgling and begin to pump nourishment into it. The hummingbird with eggs seemed a trifle fearful of her neighbor with nestlings, for

on two occasions she suddenly flew away as the other came to attend them. Once she continued to sit while the young birds received their meal, only to dart away as her neighbor was leaving.

No violet-throated male appeared on the scene; in fact, I never saw a single male Guimet's Hummingbird anywhere along the stream. At this season the more brilliant sex was to be found on sunny perches near the edge of the forest, each bird sounding his metallic little voice through all the long, bright day and interrupting his animated but tuneless song only to moisten his throat at the inexhaustible fount of the flowers. Often four or five of the Guimet's Hummingbirds sang close together, but each on his own perch, to which he returned after every brief absence. So the males let the other sex know that they waited to woo them; but never once did they give assistance in the care of the nest.

While seated on the boulder watching the two nests above the forest stream, I was assailed by that uncomfortable feeling I sometimes experience in the woods, of being myself watched by unseen eyes. Suddenly, a long black snake, mottled with yellow, glided down an oblique ledge of the cliff on my right. It moved rapidly without a pause until it came to rest on a rock in midstream, almost beneath the two nestlings. There it lay motionless with its head lifted high, looking up at the young hummingbirds and without much doubt considering in dull serpentine fashion how it could reach them. Knowing from repeated unhappy experiences the insatiable appetite of the mica (*Spilotes pullatus*) for eggs and nestlings, I resolved to remove all possibility of tragedy. A snake intent upon ravin appears to become insensible to everything else, at times even to mortal wounds. This one was no exception to the rule and lingered immobile while I approached and delivered the stroke that sent it writhing madly into the water, where the current bore it slowly down the stream to die.

Feeling that the hummingbirds were safe for the moment, I continued upstream until I found my way blocked by a wall of rock ten feet high, stretching transversely across the channel. At this point the current was divided into two separate falls, like Niagara in miniature. That on the right dropped with a single leap into a deep, shady recess in the rock. The left branch babbled down among great loose boulders, beneath a huge block of rock which, wedged between the central pier of stone and the high cliff that formed the left wall of the ravine, made a natural bridge over the cascade. Like most of the wider rocks above the reach of the flood waters, this bridge was profusely overgrown with begonias, aroids, clusias, and other plants. I was obliged to crawl beneath this verdant rock bridge in order to gain the top of the wall that obstructed the channel. Passing under the bridge, I almost brushed against a neat little nest that hung above the cascade. It was attached to a splinter beneath the butt of a huge shattered tree trunk lying in the stream bed above. The nest was of pyriform shape with a round entrance in the side, shielded by a visor-like projection; its walls were composed almost wholly of fibrous rootlets and the interior amply lined with light-colored bast fibers finely shredded and some tufts of silky seed down. In this cozy retreat so excellently concealed rested a single pin-feathered nestling, which cried shrilly when I illuminated its nursery with a small electric bulb and looked in with a tiny mirror.

I could not even guess who the maker and owner of this ingeniously hidden nest might be and sat upon the central pier of rock to await her approach. After an hour a tiny flycatcher (*Leptopogon superciliaris*), gray and olive-green and pale yellow, arrived with a small green

tree cricket in her bill. Nervous and shy, she approached and left her nest by darting beneath the bridge of rock, thereby making it still more difficult for hostile eyes to follow her movements. Yet she fed the nestling while I rested in plain view only ten feet off—three feedings in as many hours.

Of a sudden as I watched I was startled by loud, shrill cries rising out of the deep recess at my right, into which more than half the flow of the stream leapt down in a single unbroken fall. Leaning over the overhanging wall of rock, I peered into the obscurity of the chasm without being able to discern more than rock and water—nothing that could possibly utter such earsplitting cries. But the shrill notes continued; so I descended by way of the gentler cascade on the other side, beneath the bridging rock, crept along the base of the abrupt wall, and peered into the recess from the front. There, on the wet, slippery, overhanging face of rock behind the falling water, clung two big, black swifts with narrow white collars. Crying loudly, at short intervals they fluttered from one point on the rock to another. Their hurried movements and sharp cries suggested great excitement. All at once they brushed past me, rose through the narrow chasm between the tree trunks that marked the course of the brook, and vanished into the illimitable vastness above. Nor did they return during the next hour. Numberless times I had watched great flocks of these largest of Central American swifts wheeling with shrill cries far overhead but never before had I come so close to them. They are said to nest in crannies in cliffs and possibly, like the Black Swift, they sometimes attach their nests behind a waterfall. Removing shoes and socks, I waded into the alcove behind the falls (not without a wetting) but could find no indication of a nest nor any cranny that might have supported one. Probably these White-collared Swifts (*Streptoprocne zonaris*) were disappointed in their quest for a nest site, as I, upon my return a fortnight later, was disappointed in my desire to learn something about their home life.

The afternoon was now more than half spent, and I turned homeward, to make sure of reaching the clearing before it grew dark. I was climbing down the long ramp of rock above the big pool, passing over a narrow and slippery ledge in the cataract on its left side and thinking how unpleasant it would be to meet, in that insecure position, the huge snake that had left its slough upon the neighboring slope, when a creature of quite a different character appeared. A hummingbird flew out of the forest and clung to the inclined rock surface over which the water poured in a thin sheet, almost at my feet. First he appeared to drink, then bathed, pushing his head down into the flowing water, shaking his wings, and wetting himself all over. He was big for a hummingbird and had a long, straight, black bill and a deeply forked, black tail. His upper plumage was green; and I caught shifting glints of intense, metallic blue from his throat. He quite ignored my presence, even when to save myself from falling I shifted my position. Then he brushed past to perch in a low bush close behind me, shake the water from his plumage, and put it in order. Before I could maneuver myself into a position to view him favorably in the dim light, he was gone, unidentified in the terms of science, yet ever to be identified in memory with this beautiful cataract in the course of an enchanting sylvan stream. Thenceforth, the highest fall on the Hummingbirds' Brook was known as the "Hummingbird Cascades."

ART CHEMISTRY

By STANKO MIHOLIĆ

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WHEN the Roman poet Horace in a moment of exaltation asserted that his poems would outlast bronze, he was not so far wrong after all. Because more than poetry or music, which may be preserved by oral tradition, art is dependent on matter, and many works of art have been lost forever because the material from which they have been made has decayed with time or has been destroyed altogether. This is particularly the case where unsuitable material or a wrong technique has been employed.

There are innumerable instances of deteriorated or lost works of art. All that we know of classical Greek painting are names of artists and descriptions of some of their principal works in the handbook for travelers in Greece by Pausanias. From Polygnotus, Apollodorus, Parrhasius, Nicias, or Aristeides not a picture has survived. Their works were executed in the archaic technique of encaustic. The pigments were mixed with beeswax, and the mixture applied with hot bronze tools to wooden boards. Another method was to lay on the molten wax, mixed with the pigment, with a brush. As both beeswax and wood are rather frail materials, it is no wonder that nothing has survived the ages.

Many statues of the early Middle Ages in Western and Middle Europe, especially on the outside of buildings, have become defaced because they were cut from sandstone that easily weathers away.

A similar fate befell some of the works of Leonardo da Vinci. His famous painting "The Last Supper" in the refectory of the former Dominican convent, Santa Maria delle Grazie, in Milan, considered by many one of the best works of medieval art, is now practically lost. In order to avoid the difficulties connected with the fresco technique, where the picture has to be finished while the freshly plastered wall is still damp, he used the tempera technique, where the pigments are mixed with egg yolk and applied on a specially prepared wall surface. This gave him the opportunity to work slowly and carefully, but the technique itself was entirely unsuitable for a wall painting in the damp Lombardian climate. The artist himself lived to see the doom of his best painting. That only wrong technique was the cause of the loss of this picture becomes obvious from the fact that in the same room some fresco paintings made about the same time by an obscure Italian painter remained perfectly fresh. Another work of art by Leonardo da Vinci, a colossal statue of Lodovico Moro made from specially prepared clay, was entirely lost during the lifetime of the artist.

Many students of art have wondered about the chiaroscuro of old Dutch paintings, especially those by Rembrandt. Chiaroscuro is a manner of painting where the faces of personages are represented as high lights on an utterly dark background. The effect is only partly due to the intention of the artist himself; it is much more a sign of deterioration of the picture. The Dutch painters used white lead liberally in their paintings. This produced a marvelous paint but one apt to darken with time and become almost black. For the faces they did not use this paint which explains the present state of the pictures.

Unsuitable painting material caused

much damage in the nineteenth century. With the rapid advance of science and the discovery of new materials, painters came to use pigments before their durability was thoroughly established. Makart, a Viennese painter very popular in the 1880's, achieved very pretty effects by using a solution of asphalt in oil as a warm brown paint. Asphalt, however, darkens with time even faster than does white lead, with the result that some of his pictures had to be withdrawn from the museum because they grew so dark. The aniline dyes, beautiful and brilliant at first, deteriorate the other way around. They bleach in the light, and many paintings painted in the last quarter of the nineteenth century are now faded out or are almost blank.

These works of art are owned only by museums and rich people, but there is another instance of deterioration that affects practically everyone. I mean the decay of engravings and old books. Booklovers all over the world note with regret the deterioration of books even in the short span of a human life. It was not always so. Books written on vellum many centuries ago are still in perfect condition; books printed two or three hundred years ago are still in good condition; whereas books printed only a few decades ago often fall to pieces between the fingers of the reader. Bruce Lockhard lectured some years ago on the theme, "Will books survive?" Considering what I have just said, we might repeat his question from an entirely different point of view. Rossiter Johnson wrote in 1891 that "centuries hence some bibliographer will construct an ingenious theory to explain why no books were printed between 1870 and 19—, the date at which we accomplish the destruction of the forests and begin again on cotton."

Why has modern paper such low durability as compared with paper made from rags a hundred and fifty or more years ago? The first reason is that wood pulp is used in the manufacture of paper. Wood contains a substance called lignin, which withers easily and causes the paper to become yellow and brittle in a few years. As practically all newspapers are printed on such paper, complicated methods for preservation have been devised, since newspapers are stored in libraries as valuable material for future historians. One method consists in pasting sheets of transparent Japan paper on both sides of the newspaper sheet—a very expensive method indeed, for the conservation of an ordinary daily paper in this way would amount to several hundred dollars a year. The other reason for the low durability of modern papers is the careless use of bleaching chemicals. In order to get perfectly white paper, the pulp has to be bleached. If, after bleaching, the chemicals are not carefully washed out and the paper is sized with resin (an ordinary procedure to make paper stronger and less permeable for ink), it will become brittle and brown in a short time even if it is made from rags.

Paper can be damaged in other ways, too. There are first of all insects that eat their way through books or, rather, through the bindings of books. There are few books over three hundred years old which do not show traces of insects having been busy with them. Another, still greater, nuisance is the so-called foxing of paper. The ugly rusty spots that appear on many books and engravings, especially if kept in dark, damp rooms, were formerly ascribed to insects, but Pierre See proved in 1919 beyond doubt that the damage is caused by different kinds of mildew. Later investigations carried out in England have shown that only paper that contains traces of iron gets foxy. The question of foxing on books and engravings has become particularly acute in the past few years. In case of war, books and other

works of art have to be stored in cellars for protection against air raids, and such places are very likely to be both dark and damp. In the first World War pastels by Maurice-Quentin de La Tour owned by the local museum in St. Quentin had to be stored in a cellar, and some of them got badly and irreparably foxy.

From the examples just mentioned, we see the importance of the durability of the material for the survival of works of art. One of the first tasks of art chemistry is therefore the investigation of durability of materials used in art.

ANOTHER interesting chapter in art chemistry is the rediscovery of lost techniques. There are many instances where techniques used for many years have been entirely lost.

The art of making dark red glass, exercised by the Romans and Byzantines, was lost in the early Middle Ages, to be rediscovered by the German alchemist Kunkel about 1680. The art of making Egyptian blue, a beautiful blue pigment consisting of a calcium-copper silicate known in Egypt from the Sixth Dynasty, was lost between the second and seventh century of our era. To make this blue, sand was mixed with copper carbonate, lime, and a little soda and kept at a temperature between 800° C. and 900° C. for about twenty-four hours. Below 800° C. the blue is not formed, and above 900° C. a green glass is obtained, so the temperature has to be carefully regulated. Another lost art was the use of the beautiful crimson pigment prepared from Murex. It was the privilege of royalty to wear garments dyed with that dye, and it was only in the nineteenth century that the procedure was rediscovered. In the 1870's Schliemann discovered in Mycenae gold vessels dating from about 1000 B.C. with a remarkable velvet luster that could not be duplicated by any modern art. It was only a few years ago that an English jeweler rediscovered the technique. He applied gold dust under water with a brush to a gold surface coated with solder and subsequently heated the object till the solder melted.

There are lost arts that have not so far been rediscovered. Petronius Arbiter tells the story of an artisan who in the reign of Emperor Tiberius discovered malleable glass. He showed a vessel made from this glass to the emperor and then threw it on the floor. The vessel got dented but did not break. The artisan then took a hammer and repaired the vessel. The emperor became fearful lest gold and silver would lose their value and asked the artisan whether he had disclosed his secret to anyone. Though the artisan denied this, the emperor ordered his execution to stamp out such a dangerous invention. This story is also mentioned by Pliny. Although we have now a series of flexible, transparent, organic substances that are widely used, the art of making malleable glass has not been rediscovered. Another lost art is the making of malleable bronze, supposed to have been known in some countries three thousand years before our era and never known since.

The third task of art chemistry is the investigation of the genuineness of art objects and the discovery of frauds. As art objects sometimes achieve very high prices, the incentive for falsification is great. A thorough chemical analysis in many cases will show the fraud. Pictures where aniline dyes were used cannot have been painted before 1870. Another possibility is the determination of the refractive index of linseed oil used in the preparation of oil paints. A. P. Laurie has shown that the index increases in eight days from 1.480 to 1.494; in one year to 1.500; in three years to 1.512. The refractive index of linseed oil used in a painting from the fourteenth century was 1.600. Thus we can roughly date a picture by the refractive index of

its oil paint. A direct consequence of the increase of the refractive index is the fact that oil paints get duller and more translucent with age. In cases where one oil painting is made over another one, the underpainting ultimately shows through. An interesting example is a picture by Pieter de Hooch in the National Gallery in London where the floor tiles show through the dress of a woman standing by the fireplace.

Recently infrared, ultraviolet, and Roentgen rays furnished new possibilities for investigation of pictures and of the materials from which they are made. We can also determine whether some parts of the picture have been covered later by paint. Some years ago a French painter made an excellent copy of a painting by Tizian and signed the painting with his name as the copyist. The art dealer who bought the picture, wanting to sell it as an original, covered the signature of the copyist with oil paint and substituted Tizian's initials. The prospective customer, however, was cautious enough to have the picture investigated by Roentgen rays. The photograph clearly showed the signature of the French copyist.

The fourth field of art chemistry is the art of preserving and restoring works of art. In this field great advances have been made in the past fifty years. This is especially the case with objects made of metal, bronze, or iron. In former days it was customary to clean such metal objects that were covered with rust mechanically, using sand; or chemically, using acids. Important parts of the object have been lost in this way. Nowadays weak electric currents are used to reduce the metal oxides to metal again. The art object is placed as a cathode in a solution of sodium carbonate or sodium hydroxide and a very weak electric current passed through for days. In the case of bronze objects some results have been quite surprising. Coins that had practically become lumps of oxide returned to their former shape, and all the inscriptions on them became easily readable. Small statues, completely disfigured, revealed their hidden beauties again. (It is regrettable that some of the best formulas for the electrolytic restoration of bronzes are still kept secret by various experts in this field.) Small iron objects can be freed from oxide without loss of substance by placing them for fifteen minutes in molten potassium cyanide.

More complicated is the restoration of old pictures. Before starting it is necessary to know what material has been used in painting. Then the picture is cleaned. Pictures darkened with time can be made lighter if the darkening is due to white lead. Hydrogen peroxide will turn black lead sulfide to white lead sulfate and clear the colors. Asphalt, however, cannot be bleached, and cases where the darkening of a picture is due to asphalt are incurable.

Then there is the problem of foxy papers. Various formulas have been tried to prevent or stop foxing or to bleach foxy spots. Douglas Cockerell suggested an alcoholic solution of thymol, a substance sometimes used in dentistry, to stop foxing. The paper is dipped in the solution, or the solution is applied with a brush. The method is not very satisfactory, as thymol is a rather weak antiseptic. W. Haslam recommends chloride of lime instead. This is a powerful antiseptic that will not only kill the mildew, but will at the same time bleach the paper and restore it to its former whiteness. It has one disadvantage: it leaves free chlorine behind, which might destroy the paper if not carefully removed. Still others have suggested sulfur dioxide, easily obtained by burning sulfur. This is a very effective, but for the paper, extremely dangerous, substance, as it yields sulfuric acid, which in time will destroy the

paper altogether. After some experiment I have developed a formula that is a little cumbersome but which gives very satisfactory results: the paper is first put in a solution of potassium oxalate to remove traces of iron, if present; afterwards it is left for twelve hours in a 2 percent solution of chloramine, a substance used in World War I for disinfecting wounds, washed with a solution of sodium thiosulfate, then with water, sized with a warm 2 percent solution of gelatin, and then dried between sheets of white blotting paper. This method can be used to repair foxy books or engravings, but the books have to be taken apart and rebound after the procedure.

In the case of pictures, also, mildew may result from storage in dark, damp places. During the war many paintings from the Madrid museums suffered this kind of damage after being stored in cellars. A quick method of preventing foxing is therefore essential, and here, too, some new methods have been developed. New, extremely powerful, but otherwise perfectly harmless, disinfectants can be used. One method is to mix thoroughly one part of benzylester of paraoxybenzoic acid with three parts of talcum and apply the fine white powder with a brush so thinly that only an invisible layer is left. This white powder is almost insoluble in water and about eighty times as powerful as carbolic acid, itself a very strong antiseptic. It can be used to prevent the formation of mildew on furniture and books as well as on paintings.

Finally, there is the problem of the preservation and restoration of leather, particularly bookbindings. Any visitor to public libraries will have noticed the deplorable state of some bookbindings, especially of books that are very seldom used. Even here leather manufactured a century ago has shown itself stronger and more resistant than modern leathers. In 1858 a discussion was held at the Royal Society of Arts in London on the durability of leather bindings, in which it was pointed out that leather bindings appear to resist dampness better than extreme dryness. For some time the heat from gas lamps was considered responsible for the damage, but Douglas Cockerell pointed out the same damage in the British Museum Library where no gas was used. The main trouble, however, seems to lie in the indiscriminate use of strong chemicals, even of sulfuric acid, in the modern preparation of the leather. To prevent damage to bookbindings various authors have recommended a thin coating of shellac, vaseline, or of mixtures of oil and wax.

IN ACCENTUATION OF THE NEGATIVE

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THE times make opportune some re-examination of mankind's moral maxims. Reference is not mainly to war, wholesale denier of liberty, but to something more normal and retail—peacetime denials of man's will-to-independence. It is notorious that in the latest doctoring of the dictionary, "liberalism" has changed its meaning from *laissez faire* to "let us legislate"; and one may observe that there is abroad in the world the determination for many to become most meanly their brothers' keepers. We shall speak of these matters at the easy level of popular symbolism—"gold," "silver," "aluminum"—but our thought runs deeper: the danger of moral prescriptions; the fear of a new age of faith and solicitude; the hope of a political order which will maintain between men such social distance as can effectively discourage infliction of the will-to-power in the name of the will-to-perfection.

THE DOWNWARD CLIMAX OF RULES

The Golden Rule. Throughout Christendom there is available a directive for life which takes the form of law but which at the same time is supposed to loosen the rigor of the ethical absolute. "Do unto others as you would have others do unto you." In high testimonial, this has been named the "Golden Rule." It is really two rules, and we must consider its elements separately. The first element of the injunction is "do." It clearly enjoins action—and action with reference to others. It elevates into supreme importance the distinction between self and others but it seems to plump at once for altruism as the essence of obligation. We are our brothers' keepers; we are not good if detached; we veritably belong to one another; we must find the meaning of living in life's other-regarding aspect. Giving rather than getting becomes the *sine qua non* of morality. So it seems at first glance but not so completely so on second thought.

Further reflection, indeed, fixes attention on a less obvious element in the rule, an element which mitigates the rigor of pure altruism. It advertises the self as a point of departure and as the point of return. It tells us what it is that we owe a debt to *do*. We must do something to and for others, but what we owe to do is determined out of respect to what we ourselves can approve when we are on the receiving end of action. What we must do to others is indeed just what we ourselves would like if others did it to us. To apply the rule, one must first understand himself, must first respect himself, must indeed affirm himself as the standard. A rule of thoroughgoing altruism would prescribe *doing unto others as others would have us do unto them.* The altruism of the Golden Rule is made to depend upon egoism; but egoism is made to operate only in a social milieu.

Familiar enough are the difficulties adduced against the categorical imperative thus modified. They arise from the fact that a rule which seems prima facie social is ultima facie self-centered. The paradox is mitigated only by presuming a situation in which this conflict is antecedently resolved by prevailing usage. That is, the rule holds unparadoxically only between equals who are culturally like-minded. My friend, for instance, buys me a season ticket for grand opera when to grand opera I am more than insensitive; I am downright antipathetic.

My friend does this to me because, perhaps without thinking much about it, he would appreciate such a gift from me. But on the same principle a grand opera ticket would be the last gift I should think of offering him. His gift is a burden to me, and even an irritation. To the irritation he has often replied that I *ought* to like grand opera whether I do or not. He thinks that all that is required to educate me in the right direction is sufficient exposure of me to operatic exquisiteness. My friend and I are equals; otherwise we would not be friends and not be exchanging gifts. But we are not like-minded. Neither's personality is a good reference point for the other, *save upon the assumption of interventionism as the meaning of obligation.* There indeed is the rub. If we enhance the unlike-mindedness, this moral rule rendered possible by friendship will then obtrude so conspicuously as to become downright intolerable.

As a standard test, consider the savage chieftain who offered the Christian missionary a harem of the tribe's most seductive maidens. The chieftain did not understand the missionary's protest. Had he not been taught the Golden Rule by the missionary? Would he not himself expect this courtesy if he visited the missionary in the Christain homeland? The missionary could make his declination stick only by first getting overtly accepted what is the covert assumption of the rule, that he and the chieftain are not equals. The chieftain must first renounce his preferences *in favor of* those of the missionary before they can facilitate friendly intercourse on the basis of the Golden Rule.

Now this noble impartiality of self-preference, which appears to underlie the rule, not only involves an antidemocratic element but it also thinly disguises prejudice against variety as the juice of life. Men must agree upon "fundamentals," and the agreement must be in the spirit of "you and I is one, but I is de one." You can afford altruism only after altruism has, through self-reference, veered toward egoism—and then has perhaps forgotten what it has become through the operation of external factors making for sameness. The root of the defect which begins to emerge from this analysis is not so much egoism as it is interventionism. There is a lingering suspicion of priggishness in the operation of any principle which makes it the duty of one man *to do* anything to another man. "The most priggish business in the world," observed Woodrow Wilson, "is the development of one's character." Especially is this so when one seeks his own fulfillment in "doing good." Wilson should have known.

The Silver Rule. A rule which thus tends to abolish itself by passing into its opposite—other-reference here passing into self-reference—requires mitigation if it is to escape discard. Let us seek mitigation from the Golden Rule in consideration of what has been called the Silver Rule. Instead of "do" we now, with Plato and Confucius, substitute "don't do." *Don't do unto others what you would not have them do unto you.* This is clearly further from enjoining personal interventionism than is the former as a rule of life. It seems indeed to affirm the very opposite. On second thought, however, it is doubtful whether it goes so far as that. Instead of being broken up into two elements, like the first rule, this injunction hangs together as an organic unity. It does not in its most natural sense mean (1) "don't" with (2) a positive elaboration; you don't elaborate a downright negative. And yet there follows an elaboration of the "don't." So, as a matter of simple fact, the inner meaning of this "don't" is also somehow corrupted with the notion of "do."

To put it so as to bring out both the unity and the positive element: "Don't do to others what you don't want done to

you." We actually get thus as its latent meaning, "Do something other than what you don't want done to you." The Silver Rule, negative in form, is, in part at least, positive in sense, with a caution *about* interventionism rather than a forthright imperative *against* it. Interventionism with caution, it seems to imply, is better than interventionism without restraint. But interventionism is interference, however safeguarded. So if we are to seek the major positive meaning of our quest for a lessening rigor of rules, we must further mitigate what we seem not easily able to exorcise altogether.

The Aluminum Rule. Suppose we change this emphasis as nearly altogether as is possible in rule-making. Let us regard interventionism as an evil rather than a good, even though up to some point an inevitable evil. Then we would get a rule reading something like this: *Don't let others do to you what you wouldn't do to them.* This doubles the distance from interventionism by doubling the negative against it. Since it lightens the obligation of action and reserves a field for personal liberty, I have called it the "Aluminum Rule," as befits free man's passion for lightness. Aluminum is late of date, light by nature, and durable in usage.

The articulation of such a rule budges the rule-making impulse toward if not to its minimum; it saves the impulse but lightens its burden as much as is humanly possible. It does this from the thought that the burden of interventionism is more than any man can carry with modest grace. There is an animal impulse, a deep human undertow, which drives us on to make, as the poet's clairvoyance has it, "easy simplicity of lives not our own." But that this impulse is worthy of being made a part of the obligation of man is soundly to be doubted. In the spirit of a great predecessor we ask: If men cannot govern themselves, how in heaven's name can they be thought to govern one another? Men who have become masters of themselves seem always to lack much of the common drive to manage other people's lives. Indeed, a man who looks out for himself without harm to others probably becomes in so doing author of more good than the man who substitutes for independence *from,* interventionism *in,* the affairs of others.

Nevertheless, it is not enough to make a positive rule to this effect: *Let each man look after himself.* This is not enough because both the animal impetus which we have mentioned and the social tradition giving moral respectability to the impetus urge men to look after each other. Egoism is indeed thought to be morally neutral, if not downright vicious; only altruism is praised as virtuous in the copybook maxims of mankind. Since it is thus, it behooves us, if we see the matter so, to make our supreme rule the injunction of self-protection against the long-prevailing respectability of interventionism. But we have been assuming or, at best, insinuating that positive moral injunctions are bad. Let us now argue the case of abstention so that our Aluminum Rule may emerge, if emerge it can, into the light of a more liberal and loose-jointed respectability.

Upon the Wings of Negativity

Our preference for the negative has more to it than appears. It is in fact a drift from the lesser toward the greater source of value. We would indeed wean men away from nuzzling one another so that they might the better nurse their own well-being. All self-conscious civilization deplores the emphasis upon the external and glorifies the internal. The literal is lethal; only spirit produces spirituality. Now another is always external to one; not as external as sticks and stones, but not as inward as one is to himself. Those who do us the greater wrong are they who think they understand us better than we understand our-

selves. Where completest understanding is, there is man's greatest treasure.

To seek the measure of our morality in ministering to the external, that is to achieve immorality, however fondly we may caress it. Having such morality in mind, we ask with Santayana,

> Is not morality a worse enemy of spirit than immorality? Is it not more hopelessly deceptive and entangling? Those romantic poets, for instance, whose lives were often so irregular—were they not evidently far more spiritual than the good people whom they shocked?

Santayana details this latter query: Can anyone now doubt that Shelley was better than the English judge who denied him custody of his own children? Men who command their own souls and both explore and exploit their treasure—are they not always better than men who command the souls of others, wilting and withering what at the best is exotic to their full understanding?

To find the meaning of life in altruism is to locate significance in the extension rather than in the essence of value. It is not in what we *do* but in what we *are* that the first layer of value lies. To be let alone is, by this very fact, the first law of axiology. It is indeed the hidden behest which informs the genius of the American constitutional system. In the Bill of Rights the Fathers "conferred," as Justice Brandeis said in a great decision, "as against the Government, the right to be let alone—the most comprehensive of rights and the right most valued by civilized men." Not only of our Constitution but of our laws as well is this the strong continuing inner spirit. Law is normally in the negative; at least democratic law is. *You shall not do thus and so; and if you do, then this is the penalty.* Such is the spirit of the safest law. It is indeed the business of law "to hinder the hindrances," "to hurt the hurters," "to restrain the restrainers." Be it not cramped, life realizes its greatest boon, to express itself. Intervention can be justified only where it contravenes the interveners. Such circumspection leaves men free to discover and to disclose in self-expression whatever meaning life has found in itself.

Shall morality be less generous and clairvoyant of spirituality than is law? The law, which, as Hobbes said, "is the public conscience," is largely negative in form because it is positive in intent. Shall moralists be turned loose where lawgivers and policemen circumventIy if not reverently stay their hands? It is often so; but such morality turns into immorality through the very irreverence of its operation. It becomes gossip and prying and prudery; it becomes the kiss of death upon the budding bloom of life. No man is wise enough to tell man what to do. Positivity is infinite, even in presumption; negativity alone is limited. "Civilization," as Justice Holmes sagely observed, "consists in imposing limits upon the infinite." To undertake positive surveillance of other life is, in the nature of the case, to impoverish your own life with an immodesty which at the same time knocks other lives in the head at the narrows through which they must pass inspection. As initiative must be left to the positive, so negation must fall upon the negative alone.

Two Pilgrims in the Strategy of Negativity

It was the great Jefferson who early in our national history rendered this view of moral negativity sacrosanct, illustrating long before Alfred North Whitehead the latter's insight that "religion is what a man does with his solitariness." Jefferson had suffered, and that continuously, from the attacks of intolerant clergy and the tongues of prying prudes over what they supposed to be his religious heresies. They said that he was an enemy of Christianity and a traitor to the high trust of spiritual leadership. They said that he was an infidel, yea that he was an atheist; that he was a puller-down of temples which housed those more

reverent than he. Jefferson did not reply, continuously he did not reply. Upon solicitation at last from those whose intimacy permitted inquiry, Jefferson at length gave private voice to the faith that was in him. It was not too radical a faith. Indeed, it was so reminiscent of what always passed for Christian conviction, purged of superstition, that his friends besought him to make public what he believed about religion. This he would not do. They implored him to let *them* make public his beliefs, that the mouths of doubters might be stopped and the cries of enemies against him be silenced. Nor would Jefferson permit this. His friends did not understand his reticence, deepening into what they thought stubbornness, as touching what seemed to them his just and adequate defense against persecution.

To their troubled insistence Jefferson at last gave immortal reply. To one he said, "You press me to consent to the publication of my sentiments and suppose they might have effect even on sectarian bigotry. But have they not the Gospel?" To another he wrote, "No, my dear Sir, not for the world. . . . I should as soon undertake to bring the crazy skulls of Bedlam to sound understanding." And, though he submitted that he was "a Christian in the only sense in which *He* wished anyone to be," Jefferson gave to the world, as to his detractors, a refusal of right which is still radiant with wisdom:

> It behooves every man who values liberty of conscience for himself. . . . to give no example of concession, betraying the common right of independent opinion, by answering questions of faith, which the laws have left between God and himself.

Plainly and simply, Jefferson refused, and taught us to refuse, to answer questions that nobody has a right to ask. Any and every interventionism is an evil; and even when it is a necessary evil, it should be kept on the defensive.

Does this seem thorny and crabbed, the attitude which Jefferson portrayed and inculcated? Were we in heaven, Yes; since we are on earth, No. For earth our final wisdom is the Rule of Aluminum, and aluminum can be brittle as well as bright. *Don't let others do to you—even ask of you—what you would not do to, ask of, them.* This is the wisdom of Monticello. Jefferson is our first pilgrim upon this shining way of negativity. Keeping clear always the line between conduct and spirit, Jefferson adds finality to religious negativity: "It does me no injury for my neighbor to say there are twenty gods, or no god. It neither picks my pocket nor breaks my leg." Such clarity of concept and such courage of conviction constitute man's final protection *against* interventionism and the final protection *for* full self-possession of life's plainest dignity and surest values.

It remained for Jefferson not only to refuse by example to set seal upon the most Peep-Tom puerility of the morality of respectability, but for him also to make clear what is the root of his reticence. The trouble is that mankind's best are not intent upon power but rather are content with the pursuit of perfection. Now power is of the outer, but perfection is of the inner, life alone. Those who find only urgency where there ought to be essence will then prod other men, even though these others be engaged in the silent business of communing with perfection. It is the will-to-power which sees morality in personal intervention. It may be called by the noblest names but it remains always identifiable as someone's push for power. Jefferson lacked this will-to-power. Other men who had it would meddle with him; he who would not meddle would not countenance meddling. Not only did he assure his friend Dr. Rush that he considered religion "as a matter between every man and his maker, in which no other, and far less the public, had a right to meddle"; but he put the root matter before

another friend, De Tracy, in these words potent with final explanation of his attitude: "I have been unable to conceive how any rational being could propose happiness to himself from the exercise of power over others."

Jane Addams is our other pilgrim upon this way. In the estimation of her most understanding biographer, James Weber Linn, her nephew, she arrived early at this same exquisite insight: that doing good must not become "do-goodism." She had visited Tolstoy and imbibed whatever of his spirit she could take. Coming home to Hull House, she found herself frustrated, in things external, by West Side Chicago politicians. She set about to defeat the alderman of her district; and into the enterprise, as was her wont, she poured time, energy, and money. She awakened from the plunge in externalism to discover that the politician had "beaten her to a frazzle." Her friends expected her to come back, renew the struggle, and keep at it until the ward was hers. This she did not do. To their surprise she replied that she was giving up the contest. And to their greater surprise she gave as reason for her withdrawal from the contest that the politician had taught her a most valuable lesson, the lesson that he understood the people of Hull-House district better than did she. Among other things, she meant that he was not meddling in their mores. Out of gratitude she was disposed to work with him rather than against him henceforth. The relation thus defined on solid inner foundations of mutual understanding and respectful abstention was a long and fruitful one, not unbeautiful as her biographer unfolds it through the years.

So far as understanding is the main thing—and is there limit to its merit?—the internal's the thing in the life of value. The greater negativity we can achieve against man's urge to intermeddle with man, the more positive the efflorescence of the spirit. That is the law which underlies all law. Such a law has as its overt witness some such attitude as we have sought to present in the Aluminum Rule. The negativity of our formulation will not obscure its contribution to the affirmative life of the spirit.

The truth is that we start with a thousand and one interventions in the name of morality. Moreover, if as animals we did not already start with them, we should soon achieve them in the medley of social living. Men are forever in conflict, each pursuing his interests across the line that intersects the others' orbits. These interests-in-conflict enmantle themselves in moral principles, and the result is that men are ever and anon impaling the conscience of others upon the bayonets of their own. Man's fullest perfection is forever being crucified upon the cross of power. Since man's will-to-power, which each must somehow exemplify in order to live at all, drives us across one another's bailiwicks, our only salvation is some guarantee that the will-to-perfection will find sanctuary in the lapse. The symbol of this lapse is the reluctance to intervene in one another's lives even in the name of conscience. That reluctance is, however, so often victim of the deep undertow to make principle coincident with interest that we need whatever support we can achieve of its superior virtue. Whatever rule can dramatize the superiority of the negative in the strategy of the spirit is useful and right. That is all we have here tried to do; and that, if done, is enough.

Our Reign of Rules in Résumé

Beneficent as the negative is in the life of the spirit, it requires no monopoly. Each rule reigns in proper turn. The Golden Rule has its utility in groups which if not always small are nevertheless like-minded. Now, since every life has its nexus of little loyalties, the rule is wisdom where it is realizable in mutuality. Its relevance is measured by the

limits of like-mindedness. Its best locus is perhaps the family: parents to children—like-minded but unequal. I was about to say that its virtue lies in its being a prod to universalize like-mindedness. That would be, however, to fall into the error to which moral motivation is peculiarly susceptible. The larger truth is not only that universal like-mindedness is impossible but also that it would be of less value than the variety constituted by unlike-mindedness. The value here involved is protected by the natural fact that beyond a point we cannot perpetrate what we ought not of interventionism. Power tends to limit itself by the counteraggression which it provokes.

Where perfection fails of protection from this principle, another rule comes to succor value. Since we cannot extend even our "golden" provinciality unto universality, the Silver Rule is in extension more "golden" than the Golden Rule. Where positive concern turns through social distance into psychic indifference, we water down our urgency into the Silver Rule of moderated interventionism. Not to do to others what we would not have them do to us is to invest with proper moral meaning the natural indifference men feel toward those beyond their borders and toward the unlike-minded within those borders.

Within our national borders we have, through our emphasis upon the Bill of Rights, achieved the right to be alone without too much waving of our aluminum principle. And beyond our borders we have become masters in large part of our ancient will-to-intervene. Distance, physical or psychic, has relieved us of our own will-to-invade. Unfortunately, others have not grown with us into moral neutrality. Against them as a rule of life we need something more tough than silver or gold. Literal aluminum in the earth must be matched by a pertinacity of spirit which we have symbolized as aluminum in the soul. So long as their bellicosity threatens to arise again, we find the apotheosis of honor in the rule that they shall not do to us what we would not do to them. Whoever would in such plight substitute a better rule than this will find himself exemplifying a worse one. When tolerance meets the savagery of interventionism, impulses of vengeance may prove most wholesome as defenses. Better to liquidate such enemies than be liquidated by them.

The last reliance of human dignity is the maintenance of some such attitude as this negative one. The Aluminum Rule transcends in utility every dictate of interventionism and so supplants in universality both the Silver and Golden Rules of life. Who loses this aluminum protection loses both his silver and gold; and who saves his life in habilaments dishonorable loses all that life's about. Not even the like-minded are privileged to violate this rule, though since they will not ordinarily wish to violate it, its tyranny over them is mild. The unlike-minded whom we tolerate cannot step over this line, but, since they will not within our borders ordinarily insist upon violating our privacy, they need little feel the brittle of this rule of exclusion. Should either so far forget friendship or civility as to stoop to "mauling," the rule rises to defend the integrity of the spirit against those who forget the true vocation of man. When those from beyond the pale make bold to ride through the outer defenses of tolerance, then of civility, and then of friendliness, this rule constitutes the final bulwark of integrity against invasion. It is the spirit's last ditch against dishonor and so the first principle of a philosophy of life which reinforces wisdom with courage. It is not the paradoxical law "that there shall be *no* law," but the wisdom that there shall be for us no *alien* law.

ATOMIC AND MOLECULAR ENERGIES*

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THE period of modern physics, which began with Roentgen's discovery of the X-ray fifty years ago, is unique in the history of science. Never before have so many fundamental discoveries been made in the span of half a century. Never since Copernicus have scientists been compelled so thoroughly to admit the limitations of even their basic ideas and adopt new modes of thought in order to comprehend essentially new phenomena. Since the recognition of this aspect of modern physics may well serve as a valuable guide in our search for a proper attitude toward the difficult political problem which has recently been created by atomic scientists, it will be stressed in the present discussion.

The exploration of atomic and molecular structure has been the primary concern of physicists during the past fifty years, and a major part of their efforts has been directed toward the study of atomic and molecular energies The concept of energy, now regarded as basic and indispensable in every one of the natural sciences, took shape very slowly in mechanics, which next to descriptive astronomy is the oldest part of physical science. In classical mechanics the energy concept is not absolutely essential, and it is derived from other concepts which are regarded as more fundamental. Only in the formulation of mechanics given by Hamilton about a hundred years ago does the idea of energy play a central role.

In the early part of the nineteenth century the desire to improve the steam engine led to various efforts to understand the nature of heat and to discover the relation between heat and mechanical work. In the 1840's Mayer and Helmholtz in Germany, Colding in Denmark, and Joule in England independently arrived at the principle of the conservation of energy.

It may be of interest to note that the first to formulate this principle, Robert Mayer, was led to his discovery by a biological observation. When serving as a ship's doctor he noticed at the harbor of Surabaya in 1840 that the venous blood of the Javanese was almost as bright red as the arterial blood. This, he assumed, was because a smaller amount of oxidation is required to maintain the body temperature in the tropics than in colder climates. Two years later he announced the law of the conservation of energy, but he had great difficulty in getting his paper published and did not live to see his ideas accepted.

The principle of the conservation of energy claims that in all the changes which occur in nature there is something that remains constant, the energy. If energy of one kind disappears an equivalent amount of other forms of energy makes its appearance. Thus, when a gas is compressed at constant temperature, an amount of heat flows away from it which is equal to the work of compression. If the gas is prevented from giving off heat, its temperature goes up when it is compressed, and its so-called internal energy is increased by an amount equal to the work done.

The study of the internal energy and the closely related heat content of substances and of the changes occurring in these quantities with changes in temperature, volume, state of aggregation,

* Part of a public address delivered December 7, 1945, under the auspices of the Oklahoma Academy of Science.

chemical composition, and so on has become a very important field of research.

When the concept of energy is extended to new phenomena, the procedure is always to search for a quantity which makes its appearance when energy of known forms disappears. Thus, the definition of energy depends essentially upon the law of the conservation of energy. For a long time it was believed that all forms of energy are really mechanical in nature; in particular, the internal energy of a body was regarded as mechanical energy of the randomly moving molecules of which the body was believed to be composed.

However, as the study of the electromagnetic phenomena progressed, it was found that the principle of the conservation of energy could be upheld only by assuming that energy resides in the space surrounding electrically charged bodies. It was also found necessary to ascribe momentum to the electromagnetic field, even in empty space. When a charged particle moves with constant velocity the energy in the field simply moves along with the particle. However, classical theory predicts that when the velocity of the particle varies, electromagnetic energy should be radiated with the speed of light. It is perhaps clear that the application of the ideas of energy and momentum to the electromagnetic phenomena required a renunciation of the intuitive character of these concepts, which now took on a broader meaning and ceased to be purely mechanical concepts.

The theory of relativity led to a revision of classical mechanics and to a modified expression for the kinetic energy of a moving body. Moreover, by combining the conservation laws for energy and momentum with the principle of relativity, Einstein was led to the startling conclusion that all energy has inertia, or mass, which can be computed by dividing the energy by the square of the speed of light. Since this is a very large number—nine followed by twenty zeros if c.g.s. units are used—the mass associated with ordinary amounts of energy is usually far too small to be detected.

But if all energy has mass the question naturally arises whether all mass is not a manifestation of energy. If that were true even a small amount of mass would represent an enormous amount of energy; for to convert mass into energy we would have to multiply by nine followed by twenty zeros. Thus, one pound of any material would represent a latent energy of over ten billion kilowatt-hours.

Einstein's theory does not tell how to transform mass into energy nor even claim that such transformation is possible. Rather, it states that if any process exists in which mass is substantially reduced, then the latent energy represented by the lost mass will make its appearance as other forms of energy. When Einstein published his purely theoretical paper forty years ago no means of effecting such a release of energy was in sight. However, his bold idea stirred the imagination of physicists and guided them to remarkable discoveries, the most recent of which is now shaking the world.

The old conception that all matter is made up of a huge number of minute particles became a scientific hypothesis at the beginning of the nineteenth century in the hands of the English physician John Dalton. While many physicists, especially those who were under the influence of Kant's philosophy, still clung to the view that matter is a continuum, Dalton's assumption that chemical compounds are composed of molecules, which in turn are made up of atoms, led to great advances in chemistry. Curiously enough, toward the end of the nineteenth century many chemists,

led by Ostwald, were ready to drop the atomistic view as one which was not absolutely indispensable and which could never be verified experimentally. However, by this time the idea had taken hold among physicists, and they were already carrying out experiments which not only established the existence of atoms beyond any doubt but even gave information about the still smaller particles of which atoms are built up.

The first subatomic particle, the electron, or quantum of negative electricity, was discovered by J. J. Thomson in 1897. Immediately afterwards Lorentz, through his explanation of the magneto-optic effect discovered a year previously by Zeeman, obtained strong evidence for the belief that electrons vibrating inside the atoms are responsible for the emission and absorption of light. However, all attempts to account for the spectra emitted by the elements, on the basis of classical mechanics and electrodynamics, failed. Similarly, Rayleigh's formula for the intensity distribution in the continuous spectrum emitted by a black body, which agreed very closely with the experimental data at long wave lengths, failed completely at short wave lengths. No flaw could be found in Rayleigh's derivation. Thus, it became apparent that atomic phenomena are not governed by the laws of classical physics, which had been regarded by physicists and certain philosophers as having universal validity.

The gradual renunciation of many of the basic ideas of classical physics and the successful search for new principles leading to an understanding of the atomic phenomena began in the year 1900 when the German physicist Max Planck, in order to obtain a formula for the intensity distribution in the black body radiation, reluctantly made the radical assumption that atoms do not emit or absorb electromagnetic energy continuously but intermittently, in quanta which are proportional to the frequency.

Since the black body radiation depends only upon the temperature and not at all upon the chemical composition of the black body, Planck's theory could give no information about the structure of atoms. However, in 1911 Rutherford discovered that the entire positive charge and practically all the mass of an atom are concentrated in a nucleus having a diameter about ten thousand times as small as the over-all diameter of the atom. Two years later Niels Bohr, making even greater departures from classical physics than had Planck, created his famous quantum theory of atomic structure and spectral lines. This theory was extremely fruitful for more than a decade and led to a remarkably detailed knowledge of the systems of electrons which surround the nuclei of the different chemical elements. In spite of the many successes of the Bohr theory, it gradually became clear that even this theory was not radical enough. However, by 1927 Heisenberg, De Broglie, Schrödinger, Bohr, and others had succeeded in working out a new theory, the so-called quantum mechanics, which provides an adequate basis for the understanding of practically all the known atomic and molecular phenomena. The difficulty which most people experience in grasping this theory is caused by the fact that it requires them to give up some of the ideals which classical physics strove to attain and to learn to use such concepts as energy and momentum in a strange new manner.

As first realized by Bohr, an atom or a molecule can exist more or less permanently only in certain states which are characterized by definite energy values. An atom in a state of high energy may spontaneously undergo a

transition to a stationary state of lower energy. In this process, which cannot be subdivided and hence cannot be described in detail, a rearrangement occurs in the motions of the electrons revolving around the nucleus, and electromagnetic radiation is emitted having a frequency which is proportional to the difference between the energies in the initial and the final state. If an atom in the lower energy state is illuminated by light of this same frequency the reverse transition may occur, that is, light energy may be absorbed and the atom raised to the higher energy level. Thus, when the frequencies emitted or absorbed by a substance are measured by means of a spectrometer, it is possible to determine the energy values in which its atoms or molecules can exist. In some cases thousands of energy levels have been measured.

When an atom is known to be in a given stationary state, no description in terms of time can be given of the electrons within the atom. Any observation of the time when an electron inside an atom passes a certain position would throw the atom over into another stationary state. Thus, it is impossible in principle to follow the path of an electron inside an atom. We must therefore shape our thinking about atoms in such a manner that we are not led to form intuitive pictures about the electronic motions. Furthermore, since any observation of an electron in an atom leads to a break in the causal chain, we are forced to forego a causal description and be satisfied with statistical laws for the atomic phenomena.

Under these circumstances it is remarkable that the principles of the conservation of energy and momentum have been found to hold for all known atomic processes. Several times during the development of the atomic theory phenomena have been discovered which seemed to violate the conservation laws, but further investigation always led to the validation of these laws. It should be pointed out, however, that to uphold the principles of the conservation of energy and momentum it has been necessary to create the idea of light quanta, or photons, and to assume the existence of a particle, the so-called neutrino, which is not directly observable.

Except for the lowest, most stable, state the energy values of atoms and molecules in stationary states are not absolutely sharp. Rather, the width of an energy level is proportional to the probability that the atom will spontaneously jump to any of the lower energy levels in unit time. This follows directly from Heisenberg's famous uncertainty principle.

The energies that we have referred to here are the kinetic and potential energies of electrons and, in the case of molecules, the energies associated with vibrations and rotations of the molecule. The forces involved are essentially the electrostatic attractions between electrons and nuclei and the mutual repulsions between electrons and between nuclei. These are also the forces which bind atoms together to form molecules and bind molecules together in liquids or solids. These statements should not be taken too literally; for, in quantum theory, energy is a basic concept and the idea of force is not used. Moreover, the potential and kinetic energy functions are used in a purely formal manner, and many aspects of atomic or molecular energy, such as the so-called exchange, or resonance, energy which plays an important role in present-day theoretical chemistry, have no counterparts in classical physics. The strangeness of the quantum theory, from the classical point of view, should not surprise us; for the very existence of stable atoms and molecules with well-defined proper-

ties is entirely incomprehensible on the basis of classical ideas.

From spectroscopic measurement of atomic and molecular energies much important information can be derived about the structure of atoms and molecules, about the energy required to break up molecules in different ways, about the energy liberated in chemical reactions, and so on. If a sufficient number of the lower energy values are known for a molecule and if it is known how many stationary states correspond to each of these energy values, it is possible to compute not only the internal energy of the compound in the gaseous state but also the entropy. This important quantity, which measures the degree of disorder, can be used to determine the direction in which a given process, such as a chemical reaction, can go under given circumstances.

Two examples will indicate the magnitude of the energy values which we have to deal with. A silver atom has 47 electrons. It requires only 7.6 electron volts to remove the very outermost electron from the atom but it takes 25,000 electron volts to pull out one of the two electrons which are closest to the nucleus. By an electron volt is meant the energy acquired by an electron when it falls through a potential difference of one volt.

When one molecule of methane unites with two molecules of oxygen in a gas furnace, 9.2 electron volts of energy are liberated. When no electronic rearrangements are involved in the processes, the energy changes are much smaller. Thus, the spacing between the vibrational energy values of molecules is usually of the order of a tenth of an electron volt or less. The energy values corresponding to different states of rotation lie even closer together, the spacing being usually less than a ten-thousandth of an electron volt.

THE processes which occur in nature can be roughly divided into those which involve the electrons revolving around atomic nuclei and those which involve changes in the nuclei. All optical and chemical processes and most other known phenomena are electronic in nature. These processes can be more or less readily influenced by varying the temperature, the pressure, or other experimental conditions. On the other hand, the radioactive phenomena, which were discovered and studied by Becquerel, the Curies, Rutherford, and others, are associated with processes going on inside the nuclei of the heaviest atoms. For a long time all attempts at influencing or controlling these processes were of no avail. The reason for this, as well as for the failure of the alchemists, is that atomic nuclei are vastly more stable than the electronic structures surrounding them. To disturb or break up a nucleus the most violent means are required.

The first to succeed in changing the nucleus of an atom was Rutherford, who in 1919 bombarded nitrogen with α-particles and changed it into oxygen and hydrogen. More recently, especially after the invention of the cyclotron and other devices for producing streams of hydrogen, deuterium, or helium nuclei having kinetic energies of several million electron volts, many other artificial transmutations of elements have been accomplished. In many cases it has been possible to measure both the change in mass produced and the energy released in the nuclear reaction, and in all such cases Einstein's principle of the equivalence of mass and energy has been verified.

In 1930 Bothe and Becker in Germany discovered that when beryllium is bombarded with α-particles from polonium some very penetrating rays are emitted. Somewhat later Irène Curie and her husband, Joliot, found that when these new

rays fall on matter containing hydrogen, protons (hydrogen nuclei) are ejected with enormous speeds. Chadwick, in England, repeated these experiments and in 1932 was able to prove that the penetrating rays discovered by Bothe and Becker consist of an entirely new kind of particle which has about the same mass as a proton but no electric change.

The discovery of this new particle, which Chadwick called the neutron, had tremendous consequences. Immediately after Chadwick's discovery it was suggested by Iwanenko and by Heisenberg that all atomic nuclei are built up of neutrons and protons, and this view has received general acceptance.

The extremely large binding energy which holds the neutrons and protons together is a kind of energy never before recognized by man. Heisenberg and Majorana assumed that the peculiar saturation character of the forces between neutrons and protons is connected with a transfer of the charge and the spin from the proton to the neutron and back again. Thus, each particle is assumed to be alternatingly proton and neutron, or the proton and the neutron are regarded as two different states of a single elementary particle, sometimes called the nucleon.

The Japanese physicist Yukawa conceived of a different kind of transformation of a proton into a neutron and predicted that a new kind of particle, having a mass intermediate between the mass of an electron and that of a proton, should be ejected in the process. Such a particle, the so-called mesotron, was shortly afterwards found in cosmic rays. According to Yukawa, it is related to the field of nucleons in much the same way as the light quantum, or photon, is related to the electromagnetic field.

In 1934 Fermi, then in Italy, reported a series of experiments in which a large number of the chemical elements were bombarded with neutrons. Since a neutron has no electric charge, it is not repelled by an atomic nucleus and hence can pass right into it, thus forming a new nucleus which usually is radioactive. A large number of such man-made radioactive forms of the common elements are known, and they are beginning to find important uses in chemical and biological research and in medicine.

In the 1930's a large amount of information was obtained about atomic nuclei. In particular, the energies in the various stationary states were determined for a number of nuclei. Whereas the spacing of the lowest *electronic* energy levels of an atom is a few electron volts, the spacing between the lowest *nuclear* energy levels are of the order of one million electron volts. A theory which provides a general understanding of nuclear structure and energy levels was given by Bohr.

In 1939 a remarkable new phenomenon, the so-called fission, was discovered. Fermi and others had bombarded uranium with neutrons and had obtained complicated results which they were unable to explain satisfactorily. Late in 1938 Hahn and Strassmann in Germany identified one of the reaction products as a radioactive form of barium. Lise Meitner and Frisch immediately concluded on the basis of Bohr's theory that the barium must have been produced by a splitting, or *fission,* of the uranium atom in two nearly equal parts. This idea was brought to America by Bohr in January 1939 and shortly after his arrival was verified at Columbia University, at the Carnegie Institution, at the University of California, and at Johns Hopkins, as well as in Copenhagen and Paris.

It was predicted and verified that about two hundred million electron volts

of energy are released when a uranium atom undergoes fission. This can be understood from a consideration of the atomic masses of the various chemical elements. The elements of intermediate atomic mass are the most stable, as shown by the fact that for them the difference between the sum of the masses of the neutrons and protons making up their nuclei and the nuclear mass is greater than for the very light elements and for the very heavy elements. In fact, for elements like barium the mass of the nucleus is about 1 percent less than the sum of the masses of the separated nuclear particles. For uranium, on the other hand, because of the greater effect of the repulsion between the protons within the nucleus, the nuclear mass is only 0.9 percent smaller than the mass of the neutrons and protons separately. Thus, when a uranium nucleus breaks up into two more or less equal fragments, about 0.1 percent of the mass disappears. This is converted into kinetic energy of the fragments. A simple calculation shows that if it were possible to cause all the atoms in one pound of uranium to undergo fission, about ten million kilowatt-hours of energy would be released.

When it was found that two or three neutrons are ejected in the fission process, the question immediately arose whether it might not be possible to produce a self-perpetuating chain of fission processes and thus release this tremendous amount of energy.

It was soon realized that the ordinary form of uranium, of atomic mass 238, would not be suitable for such a chain reaction since it does not undergo fission when bombarded with slow neutrons. It was believed, however, that a chain reaction might be set up in the rare uranium isotope of mass 235. It was suggested also that a new element, now called plutonium, which is formed by neutron bombardment of U-238, might be suitable.

Fermi and other refugees from Hitler's and Mussolini's Europe succeeded in persuading the government to back researches on the production of U-235 and plutonium and on the explosive release of nuclear energy by fission. This work was carried on for some time on a modest scale, but after a nuclear chain reaction had been actually produced by the end of 1942 the project assumed gigantic proportions. Everyone is familiar with the outcome.

WILL BIOLOGICAL WARFARE INCLUDE PLANT DISEASE?

EVEN more diabolical than the atomic bombs promised us for the war of the future are the weapons of biological warfare so vividly portrayed in Sidney Shalett's recent article in *Collier's* (June 15, 1946)—attack with the invisible infectious agents of botulism, plague, rinderpest, and other decimating diseases of man and livestock. Newspaper articles have suggested that the agents of crop disease might be used in similar destructive fashion. Between the positions of the alarmist and the ostrich is a broad middle ground for conjecture on scientific bases. There is as much danger in overrating as in underestimating potential weapons of offense. What can we expect of plant disease as a weapon in this dreaded war of the future?

The agents of disease are manifold but specialized. Each has its particular, favorite, or exclusive targets. In biological warfare there are three targets: *man*—a single species of paramount importance to himself; *livestock*—a very few species of secondary importance in the survival of man; and *crops*—many species, *in toto* of primary importance in man's survival. We may consider the effects of enemy-induced attack on each of these as separate actions.

The attack on man has been admirably discussed by Shalett. Here we have a single species, vulnerable to several dangerous microorganisms and in a position to be mass-infected by virtue of man's congestion in cities, social intercourse, and dependence on easily contaminated infection sources such as water and milk supplies and canned foods. This, combined with the fact that man considers himself the most important biological target, indicates that biological warfare can be most destructively directed against man himself.

Next we have livestock, on which man depends for meat, eggs, milk, animal fats, wool, certain vitamins, and other less essential products. The species involved, the targets, are few; therefore, biological warfare against these targets by dissemination of the agents of rinderpest and other livestock diseases may be expected to be potentially effective. If biological warfare were even partially effective against livestock, a valuable resource that could not be replaced for a number of years would be lost. It is sometimes suggested that since livestock require as much as four pounds of food to produce one pound of meat, it is wasteful to channel carbohydrate and protein foodstuffs through animal bodies in wartime. To hold this as a legitimate argument against the danger of biological warfare aimed at livestock would be to disregard the value of the stock pile of farm animals on hand at the beginning of a war and the fact that some livestock growth and production can be made on grass and other materials that cannot be used as human food, produced on land much of which could not profitably be devoted to crop production.

The third target is the vegetable matter itself—crops. If it were possible, on a sufficiently broad scale, for a warring nation to infest vital crops of its enemy nation with destructive disease, one can conceive that the resultant blow to national economy might be a decisive factor in the outcome of the war. The collapse of Germany in World War I was clearly associated with failure of the potato crops, due largely to destructive outbreaks of the late-blight disease, which could not be effectively controlled

during war years. Recent press articles have suggested that in the event of another war the American wheat crop could be devastated by enemy introduction of foreign races of stem rust. In Peru, for example, there is a rust race, No. 189, which is particularly virulent against many rust-resistant wheats and which, if introduced and established, might conceivably wreak havoc on the millions of acres of rust-resistant American wheat. To what extent is such a possibility a real threat in a war of the future? We can best answer this by a brief analysis of the natural possibilities and limitations in plant-disease introduction.

Where the other targets of biological warfare number one or a few species, scores of species, with many varieties of each, comprise war-vital crops. In many cases the uses of different crop species are interchangeable: man can receive adequate carbohydrate nutrition from wheat, corn, potatoes, and several other crops or edible and technical oils from flax, cotton, corn, soybean, or sunflower. All these staples are annual crops: From one season to the next we can shift large acreages of one of these crops to another, and, granting the inconvenience and some lost efficiency of production in so doing, our agricultural economy is sufficiently versatile to permit substitutions of crops that could, in considerable measure, annul the effects of disaster in some one of them. We are not, as are some other nations, largely dependent on single crops for carbohydrates, oil, fibers, or other industrial products. To be effective, biological warfare directed against American crops would need to be aimed at many crops simultaneously. We are fortunate that corn, our greatest crop and the one with the most varied uses, is least subject, among the cereals, to sudden destructive disease epidemics.

Most of the agents of plant disease are restricted in their attacks to one, or very few, closely related plant species or even to a few varieties within a crop species. The stem and leaf rusts of wheat, oats, rye, barley, corn, and sorghum are all different fungi, each of practical importance on but one of these crops and each subdivided into races, any one of which will attack only certain varieties of the crop; the dreaded potato late-blight fungus is a serious threat only to potato and tomato; and so for most of the thousands of other plant pathogens. This implies that disastrous sabotage of our crops would need to involve introduction and establishment of many different agents of crop disease.

There are exceptions to this rule of crop specialization of parasites. The root-knot nematode, the fungi of damping-off, Texas root rot, Southern wilt, and charcoal rot, the viruses of tobacco and cucumber mosaic and of aster yellows, and the soft-rot bacteria each attack scores or hundreds of plant species. None of these, however, is capable of efficient dissemination by wind, which is a *sine qua non* of rapid occupation of a new area by a plant disease.

Each of the main, war-vital American crops is grown on millions of acres. To make serious inroads on war economy, a total loss of 20 percent of leading crops, a figure not far from present annual yield fluctuations, might be regarded as a conservatively estimated minimum loss. To accomplish this by enemy action would involve either an impossibly large number of malicious individual inoculations, spread over the national acreage, or the introduction, in fewer locations, of diseases which would be freely windborne over the national acreage.

This forces us to fix attention on those plant diseases that are effectively and rapidly disseminated by wind and are sufficiently harmful to have serious economic impact. We can exclude diseases spread by man in seed or propagating stock since these are amenable to our

control. We can exclude those that are poorly or not at all airborne, including soilborne infestations, virus and bacterial diseases, those caused by nematodes, and those due to many fungi which are poorly adapted to extensive aerial dispersal. Crops such as potatoes, grown in widely scattered areas, separated by long distance, mountains, or deserts which interfere with aerial dissemination of disease, would be poor targets for biological warfare. We can exclude many foreign plant diseases which, because of climatic differences or because of natural disease resistance in our crops, could not establish themselves over a wide area in the United States. Also to be excluded are those diseases that are dependent upon certain species of insects for dissemination, unless, as is unlikely, the particular insect involved is present and adapted to the living conditions over the same wide acreages.

This screening process accomplished, we are left with a rather limited assortment of sufficiently destructive plant diseases that might be suitable for biological warfare. Among these the rusts command attention, but work with them is hampered by the fact that they cannot be cultured on laboratory media and therefore cannot be propagated in quantities adequate for widespread introduction under safe, controlled conditions.

Then there is the problem of successfully establishing infestations in new areas. Every plant pathologist knows the difficulties of establishing infection in experimental plots, even with the aid of such devices as artificial watering, moisture tents, and repeated inoculation. It may be several years between seasons in which a disease will naturally take hold and spread at a dangerous rate. Even if dealing with such easily inoculated disease organisms as rust, our hypothetical saboteur would need the benefit of an unusual streak of luck or many trials to produce a successful introduction of his foreign disease on an important crop.

Assuming, however, that he has accomplished this, the chances are likewise low that the new disease will make serious inroads on the national crop within less than five years. A number of foreign plant diseases have been accidentally brought into the United States and become established, but usually the increase of these to a point where they have been serious factors in national crop production has been measured in decades.

The studies of Stakman in Minnesota and comparable data from Newton in Canada have clearly shown that a number of years is required for the build-up of new cereal rust races to practically important concentrations; and the histories of chestnut blight, the Dutch elm disease, potato wart, pine blister rust, and many other introduced diseases all testify to the length of time needed for serious involvement of the suscept crop in the new area.

Atomic warfare has impressed many with the conviction that in the next war the terrors and destructiveness of years of past wars will be compressed into a few weeks. Should this be the case, biological warfare with plant diseases would be far too slow to be decisive. But if, as some believe, the next war can be one of attrition after the first fireworks, or should we be concerned with a decade or more of prewar sabotage, deliberate introduction of foreign plant diseases might be a factor to be reckoned with. In our favor, in this case, would be the fact that this same delay would contribute to the success of plant pathologists in combatting and controlling the new diseases before they reached critically destructive proportions, as has been done many times in the past with accidentally introduced plant diseases.

If we do not subscribe to the view that biological warfare with plant disease is

capable of striking a major body blow, it is still possible that introduction of a number of foreign plant diseases could bedevil American farmers, acting as one of many secondary handicaps in production. The people of Norway and the Netherlands, during the Nazi occupation of those countries, showed us clearly the harassing effect of many minor acts of sabotage, no one of which was crucial but aggregating a total that seriously interfered with the occupation. As one of such factors, deliberately introduced crop disease could well be a harmful part of a program of organized sabotage.

In the foregoing discussion the point of view has been entirely that of danger to the United States from external sources. If one were to analyze the problem from the standpoint of hazards of biological warfare directed at other nations, not all of this discussion would apply—for example, to a country with a single-crop economy or a poorly organized program of plant-disease research and extension work.

An important contribution to American crop production was made by plant-disease scientists in the last war and will be made in the next, should it come to pass. This was not so much defense against attempted sabotage of American crops, if at all, as raising crop production through control of endemic plant diseases or those accidentally introduced—the past and probably future legitimate field of plant pathological research and education.

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BOOK REVIEWS

ANNUAL SUBTREASURY OF SCIENCE

Science Year Book of 1946. John D. Ratcliff. xxxv + 245 pp. $2.50. Doubleday & Co., Garden City, N. Y. 1946.

This is Mr. Ratcliff's fifth annual roundup of popular science. It includes 28 articles reprinted from various sources (all American) and grouped in 4 sections: Physics and Chemistry, Medicine, Agriculture, Aviation and Other Sciences. According to original publication source the score is as follows: 6 articles from *Collier's;* 5 from *The Saturday Evening Post;* 3 from *Hygeia;* 3 from *Harper's;* and 1 each from *Time, Business Week, Fortune, Argosy, American Magazine, Life, Farm Journal, Country Gentleman, Country Book Magazine,* John O'Neill's book *Almighty Atom,* and Roy Chapman Andrews' book *Meet Your Ancestors.* Four of them have appeared also in *Reader's Digest.* These statistics help to place the book so far as reader level is concerned. Also they indicate, I think, that science has attained a certain journalistic ubiquity. Whereas there used to be only two inescapables, Death and Taxes, there now are Death, Taxes, and Science.

Most of the articles are written by science writers rather than by scientists. For those who may be curious as to the varied contents of this self-jacket-styled "now-it-can-be-told record of scientific progress during the war years," the following catalogue may suffice: Atomic power (3 chapters), radar, the audion tube, radio telephones, wood and its new uses in the chemical industry, amino acids, textiles from chicken feathers, heat from cold, streptomycin, heart disease, cancer, victory over airborne germs, Rh factor in blood, surgery for otosclerosis, psychosomatic medicine, chemical weed killers, tailor-made livestock (thyroid

studies), hormones for vegetables, kudzu, DDT, rocket passenger ships, wind tunnels, long-range weather forecasting, Alaska the world's hunting ground for prehistoric animals, and finally Dr. Andrews' prognostications on the far future of *Homo sapiens*.

From this it may be surmised that by science Mr. Ratcliff means applied science. Applied science, of course, rides in the caboose and trails, sometimes at some distance, the vanguard of Science with a capital S. Which is to say that by the time a piece of new knowledge resulting from original scientific research reaches *The Saturday Evening Post* or *Collier's* it is no longer new. By that time it has been blueprinted, patented, cultivated, peat-mossed, and subtreasured by the gadgeteers. Already it has probably been applied toward the betterment of mankind, in order, for instance, that doors may open automatically before him, that he may be rocketed to the moon or blown to infinitesimal atoms, that he may perhaps live a few years longer, or that he may talk to his aged mother-in-law in Kokomo, Ind., without getting out of his easy chair. I am in no way averse to the amelioration of mankind, but I should like somehow to see him gloriously educated to the primary fact that the only genuine science is pure science and that pure science rather than spectacular spurts of "scientific development" lies at the roots of medicine, engineering, aviation, agriculture, and a hundred other practices. Neither should any new knowledge be subordinated or arbitrarily relegated to rank: there is no hierarchy of science. That is why it appears to me that such a statement as the following (from Mr. Ratcliff's introduction) is presumptuous: "Galileo, gazing through his crude telescope into the wonders of the night sky, Newton working out his laws of gravitational pull, Einstein threading his way through his unified field equations became poor primitives the day man became superman" [i.e., the day he harnessed the atom]. Why did they become poor primitives? Why did they not become gods?

Mr. Ratcliff's anthology does, however, make interesting and often exciting reading, although he employs one practice that seems to be indefensible. That is the editing of reprinted material without indicating where matter has been deleted or editorial changes made. If an article is not written well enough to be used unchanged (except perhaps for indicated bodily omissions), is it good enough to be reprinted at all? Such editing may not have been done throughout the book, but it was done in the one chapter I had occasion to check, i.e., the excerpt from Dr. Andrews' *Meet Your Ancestors*. An editor has no right to tamper with a man's published writing, be it good or bad. It is as if I should here quote Horace as saying *Nescit vox missa redacti*, whereas he actually wrote *Nescit vox missa reverti.*

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TELESCOPES AND THE MEN WHO USE THEM

Men, Mirrors, and Stars. G. Edward Pendray. x + 335 pp. Illus. $3.00. Harper and Bros. New York. 1946.

LIKE other sciences, astronomy made important contributions to the war when it loaned its practitioners for more destructive tasks than those on which they were normally engaged. Some astronomers were connected with navigation, which is an astronomical problem. Others applied their knowledge of the movements of the heavenly bodies to work in ballistics, calculating the paths of the temporary satellites of our planet which are fired from large guns. Some studied the sun in order to give forecasts on radio propagation. Others were engaged

in problems seemingly far removed from the heavens. For example, methods of preparing and using "window," the thin strips of aluminum foil which were dropped by the ton over Germany and effectively countered the enemy's radar, were largely devised by two distinguished astronomers.

But now the astronomers are back at their telescopes and measuring engines. Work on the 200-inch telescope at Mount Palomar, suspended during the war, has been resumed, and by the end of 1947 this giant instrument will be scanning the sky. The small but powerful Schmidt camera is coming into increasing use, and new techniques, some aided by war researches, are giving greater knowledge of the sun, even permitting us to see the solar corona without waiting for an eclipse.

Thus, the appearance of a new and revised edition of *Men, Mirrors, and Stars* is quite timely. When the first edition was published in 1935—a history of astronomy from the viewpoint of the men who used the telescopes—the book filled a place not otherwise occupied. It was revised in 1939, and now we have the third edition. Unfortunately, there is still no mention of David Rittenhouse, who built the first real observatory on American soil in Philadelphia by 1783. Nor is any credit given to Simon Marius, the German astronomer who used a telescope in 1609, several months prior to Galileo.

Among the new material which has been added is an up-to-date account of the 200-inch telescope and a chapter on the Schmidt telescope and the coronagraph. The list of the world's largest telescopes and the principal American (North and South) observatories, which gives their equipment, lines of research, and personnel, has been revised. Less extensive changes have been made in other chapters.

Men, Mirrors, and Stars is still the best book of its kind. Supplemented with one of the several excellent texts on astronomy, it will give the reader a good idea of how the astronomer works and what his labor reveals.

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AN AMERICAN PHYSICIAN IN CHINA

Doctors East, Doctors West. Edward H. Hume. 278 pp. Illus. $3.00. W. W. Norton & Co. New York. 1946.

CHINA is many things, subtle, complex, multidimensional, confused, and confusing to most Western minds. We are too prone to think of China as a modern state, torn it is true by internal strife, but superficially fairly uniform in culture and education, for we have read much of the dramatic and wondrous change from feudal illiteracy to literate democracy. But it isn't as simple as that. China, like an individual, is today what she is partly because of the effects of her many yesterdays. The past may be forgotten or ignored, but it nevertheless conditions the present. The recent tumultuous yesterdays before and during China's revolution profoundly influence modern Chinese thinking. Thus, Dr. Hume's delightfully whimsical and charming autobiography of his years as a medical missionary deep in the heart of China is excellent background reading for those interested in the human side of the Orient. Dr. Hume writes not of politics or economics or education or health as impersonal disciplines of thought; he writes of the personalities, prejudices, strengths, and weaknesses of the Chinese people as observed first hand in the quarter century from 1902 to 1926. As a state is but the composite of the people, one gains much insight into the present chaos.

Dr. Hume's narrative is surprisingly

and gratifyingly free of the taint of sanctimoniousness. His efforts to understand the Chinese as individuals and not only as a people were sincere and productive. He leads us to a growing respect for the Chinese classics and for the veneration of ancient authority. Above all, he demonstrates that the practice of medicine must ever remain an art no matter what level of understanding the science of medicine attains. Of scientific medicine there is little. Nor is there aught but bare mention of the now known value of some of the ancient Chinese drugs such as, for example, modern ephedrine.

The volume is illustrated with very adequate photographs. The printing is rather better than in many modern books, for the publishers have obviously taken special pains with this, their annual Norton Award prize winner. Particularly delightful are the Chinese proverbs with which Dr. Hume opens his chapters. To those of us concerned with the advancement of scientific thinking I would quote:

> If you plant for a year, plant grain
> If you plant for ten years, plant trees
> If you plant for a hundred years, plant men.

The book is worth reading.

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THE ENGINEER: SCIENTIST OR ENTREPRENEUR?

The Engineer in Society. John Mills. xix + 196 pp. $2.50. D. Van Nostrand Co., Inc., New York. 1946.

IT IS to be hoped that not too many readers will be misled by the title of this book, as was this reviewer, into hoping that it deals with a far larger subject than is in fact the case.

Part of one's disappointment arises from the author's very limited conception of what an engineer is. Following the terminology of the Bell Laboratories, the author is willing to accord the designation "engineer" only to a comparatively small group of men closely akin to researchers in pure science, though the book is more than halfway along before he explicitly says so, in the following words:

> This group of engineers and scientists . . . divides by aptitudes, and to a large extent by positions, into three classes: (1) those creatively concerned who carry on research, development and design; (2) those who select and apply to practical problems the products of the first class, like most of the engineers in public utility companies or those of manufacturing concerns; and (3) those who by aptitude and ability have progressed beyond their fellows of the first two classes into positions of management or business. . . . Most of this book has been concerned with those of the first class. . . . For purposes of this summary, and any conclusion it permits, the second class is included but the third class strictly excluded. The third class is at present necessary to society and warrants respect but it should not be included in a discussion of the engineer in society because its attitudes are inherently those of the controllers of industry, of managers, entrepreneurs, and exploiters.

It might be mentioned in passing that the above includes almost the only phrases complimentary to executives—even those in research organizations—in the whole book. Elsewhere, when executives are mentioned at all, it is usually in ways such as this:

> The production of executives is a necessity in any large organization. They must be formed, but should they be fabricated from such high priority material as research scientists represent?

This conception of an engineer is of too limited scope to justify the book's title. There are a lot of other kinds of engineers in the world besides research and development men. Indeed management is rapidly becoming not only a branch of engineering but, at least numerically speaking, its most important branch. Something like two-thirds of the graduates of the engineering schools of the United States soon find themselves working in some phase, even if a humble one, of the great field of management.

Many of us, therefore, resent the preempting of the word engineer by any limited group within the profession. We feel that the really important question which the title of this book suggests, but its author ignores, is the part which all these technically trained men are, by virtue of their training, specially fitted to play in molding the society of today and tomorrow into something even finer than can now be foreseen. Furthermore, in playing this important part, it doubtless will be precisely those engineers with executive responsibility who will have the greatest influence.

The author's small group of "engineers" may, however, be important enough to be written about, and at, as a separate group, preferably under a more appropriate title. It may even be true that, as the author says, although

> unfortunately in most cases their objectivity is limited to matters of physical science and does not extend to those of religion and psychology, politics, and economics . . . nevertheless, the fact that they are accustomed to apply the scientific method, and hence *might* [italics mine] extend it to those matters which so vitally affect our society, constitutes the only hope [the author sees] for the future.

Even then the book is a disappointing sequel to its stimulating introduction. True, three whole chapters, about a fifth of the book, are separated out in the table of contents as "A Course for Action." The gist of them is, however, only in the third of them called "Organizing for Evolution." Its first sentence is, "Scientific workers in industry should organize, I believe, for their own protection and advancement but even more for the greater social service which that will permit." A little further on this "course for action" is further elaborated:

> The immediate problem before engineers and scientists in industry is an engineering study of their class relationship to society. The first aspect of that problem is the scheme under which they receive their rewards, in other words, their pay. That is the subject which I propose for their scientific investigation. Like most research projects, as the investigation progresses, it will disclose new problems. I shall miss my guess, on the basis of other projects observed, if it does not very soon indicate a broad series of studies which will bring the engineer and scientist into fruitful contact with the major problems of our time. If the project is attacked in the objective manner of the scientific method it should lead to socially important results.

This is a definite suggestion. But if such an organization were formed, whether union-affiliated or not, this reviewer would miss his guess, on the basis of other projects observed, if it ever got far beyond its first object of study, namely, pay. The currently crystallizing groups of atomic scientists, whose activities stem from public-spirited motives in no way related to pay, seem to this reviewer to be far more hopeful signs that we are approaching a future in which scientists will be socially as well as technically useful.

Nevertheless, John Mills has written an interesting and provocative book, even if its great value has little connection with its title. Its obiter dicta, stemming from a wisdom ripened by ten years in university teaching and thirty-five years as an "engineer" in the Bell Laboratories, range from how to overcome insomnia and why women fail in technical (though not in biological) research to how to select promising young employees and how to make friends and influence people with the written word. His own writing is trenchant and, at times, exciting. He is a delightful philosopher rambling at will over the whole universe of the Bell Laboratories. If a reader does not expect what isn't there, as this reviewer did, he will find something stimulating on every page and, if he takes the trouble to digest it all, he will be a better man forever after.

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COMMENTS AND CRITICISMS

Oregon's Wonderland of the Past—The John Day

For several months I planned for this summer a trip that was to include the John Day River in Oregon. I have been interested in that area because of the gold mining days and a very pleasant journey the family took several years ago up the Deschutes River from Crater Lake. When the article by Dr. Stock appeared in the July issue of THE SCIENTIFIC MONTHLY, I was naturally very much pleased.

We took the trip. We spent a night on the gravel of Canyon Creek, gravel that was all worked over by the miners about the time of the Civil War. We saw the skull of the first man hanged in Canyon City, the skull of the second man, and many other relics of the early days, which were pretty wild.

The next day we followed the river from John Day on down to Twickenham. The Picture Gorge is well worth a trip in itself. The area is a very fine cattle country. The article by Dr. Stock was an excellent geologic guidebook.

I enjoy reading THE SCIENTIFIC MONTHLY. My own additions to the field of knowledge are practically nothing at all. My main interest, of course, is in the field of education. Seattle schools do give more emphasis to science than the recommendations of the Educational Policies Commission propose. We are trying to teach them all to appreciate this world and to think straight.—EDGAR A. STANTON.

Science and Incentives In Russia

I wish you would try to induce the *Reader's Digest* to reprint Dr. Langmuir's article in your August issue. That would enlighten the folks, since he can hardly be accused of being a fellow-traveler.

I had the good fortune to attend a lecture by Professor James W. McBain, of Stanford, given shortly after his return from the Russian trip, but I do not believe his talk was published.

Dr. Langmuir relates that a man in a good position may get as much as five times more food ration points than the ordinary mortal and comments that if a college professor or the president of a company in this country received more red points than a factory worker, there would be protests. I think he is right, but the point is that we cannot do these things directly but can and do by indirection. The president of a company could eat his fill three times a day at any restaurant, while the factory worker couldn't afford to do that. I guess this is the kind of comparison that foreigners classify as Anglo-Saxon hypocrisy.

I have been told that in England during the war the guests eating out had to produce their ration cards. That is as it should have been, and it would have discouraged the black market.—B. F. JAKOBSEN.

Immortality

This letter has two objectives:

(1) To congratulate and thank you for the very marked improvement in the MONTHLY. At one time I was strongly tempted to send in a protest against the very poor quality of many of the articles, when it occurred to me that a very large number of people who are able to write interesting and instructive articles were engaged in important war work with no time for such writing; therefore I desisted and am now mighty glad I did. The August number of the MONTHLY has much of interest for me.

(2) I should like to ask if it is not about time for you to announce that "this is positively the last word" on the immortality of the soul. I have yet to read a single article on this subject, either in the MONTHLY or elsewhere, that by the most elastic stretch of the imagination could be called scientific. The recent articles on the subject in the MONTHLY sound more like outpourings of argumentative children than the sober thoughts of real scientists. When any person has a sufficient number of well-established facts to form a reasonable conclusion on this subject, I am willing to read him, or listen to him, giving him full credit for any superior scientific qualities he may show; in the meantime, I consider that the space in my number of the MONTHLY devoted to that question could much more profitably be devoted to other subjects.—C. E. HORNE.

The Educational Policies Commission Banishes Science

It seems to me that Franklin Bobbitt [August issue] has made a most important point and one that I would like to have read by some of our superintendents and school board members out in these parts.

Incidentally, I want to again commend your entire program of encouraging our men of science to take a more active and effective part in the civic life of our nation. You have been hitting the nail squarely on the head for the

past year in pointing out how badly aloof so many of our scientific men have been and the importance of their taking an active part therein if our distinctively American type of free civilization is to continue.—J. W. CLISE.

Our Everyday Reckonings

I have been reading in the August issue the tirade of Engineer George Wetmore Colles against the metric system. Mr. Colles evidently needs someone to tell him that, according to at least one authority (G. W. Colles, SM 63, 2, 1946), "an article on the metric system, either pro or con, is by this time something worse than 'old stuff.' "

Mr. Colles expresses surprise that lawmakers would even consider the metric system. I have been told that our Founding Fathers threw over the English monetary system and actually originated a decimal system of their own.—OWENS HAND BROWNE.

On the Mathematics of Committees, Boards, and Panels

It was with amazement that the writer studied the recent [August 1946] article by Mr. Bruce S. Old in THE SCIENTIFIC MONTHLY.

Undoubtedly Mr. Old has made a valuable contribution to this abstruse branch of mathematics and deserves only the highest praise for the scholarly way in which he applies the results to practical problems. Nevertheless, one is at a loss to understand how he can have imagined that the only object of a committee is to maximize the various expressions involving ComBulPac. Granted that this usually reaches a maximum, there are cases where a minimax is sought. In such cases, the committee strives to mini-maximize its functions. This is done most successfully by prefacing the answer to any question by the Chairman by the words, "Yes, and No." What could be more simple?—JEROME FEE, Chairman, American Chairman's Association.

Tute's Philosophy

The letter from Sir Richard Tute (SM, October, 1946) contains a statement that greatly interested me, namely: "Just as every man recognizes that other men exist with personalities akin to his own, so may he recognize that every entity that exists may in its real aspect be a personality." Tute traces this philosophy —"that the whole universe is a plenum of life, mentality, or personalities"—back to Liebnitz, yet it seems to possess an origin which is certainly more primitive and probably of far greater antiquity. The Amerind, for example, believed that everything possessed its own form of life. One had only to recite the proper formula, and the slothful stone could be made to move, to live, and often to obey the will of the magician.

Tute seems to recognize the primitive character of his deduction by stating that "every religion . . . springs from intuitive knowledge of the spiritual quality of all existence." To the scientifically uncautious the faith of the Amerind may seem marvelously prescient of Tute and of the atomic bomb, but a small familiarity with the subject reveals total lack of relationship. The simple, mystical chants recorded in the Swimmer Manuscript of Cherokee sacred formulas, for example, are not the forerunners of the Manhattan Project. Similarly, the easy syllogism, the far-flung philosophy, must remain suspect if we are to retain any vestige of the scientific spirit which first flowered in ancient Greece only to be destroyed by the Neo-Platonic philosophy of medieval Christianity. Somehow, one seems to detect similarities between Tute and the Plato of the Thomists.

I am not a materialist for I am not certain that the nature of matter explains everything. Yet I am a "Darwinian biologist," for the facts of the *Origin of Species*, plus the overwhelming mass of facts added by later evolutionists, make the theory of biological advance through the operation of several factors, including natural selection, as near a sure thing as is scientifically possible. No easy syllogism, no far-flung deduction from recent physical theory, negates the titanic labors of Darwin, of Nobel Laureate Thomas Hunt Morgan, and of many, many others.

Darwin indicated that natural selection alone was not sufficient to explain the origin of species. Subsequent researches have abundantly confirmed this view. Strangely, at each tiny addition to Darwin's theory—additions which detract nothing but add further support —some scientific popularizer—too often a scientist himself—has cried that Darwinism is dead, and the philosophers use that cry to embarrass all biologists.

To believe in the existence of matter and of energy is not to deny the existence of the personality, although some definitions of this latter reality seem overextended. Tute seems to tell us that all matter may be converted to energy by appropriate techniques; therefore, matter does not exist. Similarly, the sentient being called Sir Richard Tute may be converted to a corpse by techniques used altogether too frequently of late; therefore, Tute goes the way of matter, of materialism, and of mechanism. Before he "sinks without a trace," I hope he will reveal to us the system of plumbing in his dwelling that he can be so unaware of all mechanisms.

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CONTRIBUTORS

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